KEY ELEMENTS OF SECTORAL RECOVERY AND RESILIENCE AFTER THE CANTERBURY EARTHQUAKES: A SYSTEM DYNAMICS APPROACH

A thesis submitted in partial fulfilment of the requirements for the Degree

of Doctor of Philosophy

in the Civil and Natural Resources Engineering Department

by Hlekiwe Kachali

University of Canterbury

2013

Preface

This work has come about through the contribution of many individuals and many events.

I came to Christchurch, a few days before the 4 September 2010 earthquake, with a general idea of what my research would be. That changed on 4th September 2010 at 4:35am when greater Christchurch had the first in a series of earthquakes of M_W 7.1. From a research perspective, the earthquakes brought about an invaluable research environment. However, for greater Christchurch, it was a sad moment.

In Christchurch I have seen the power that nature holds and that nature can wield. As I write this, it feels good to know that whatever the setbacks, Christchurch is on the way to recovering. Cantabrians, whatever the circumstances they have lived through and because of that experience, are determined to define for themselves who they are and who they should be.

Acknowledgements

There are so many others who have contributed in so many ways to the completion of this thesis. Thank you.

To my supervisors: Dr. Erica Seville, Associate Professor John Vargo and Professor David Elms. This thesis has involved the combination of many facets and each of you has provided a significant and unique contribution which I am greatly indebted for. As well as your guidance in the technical aspects of this research, you also have had a positive impact in my personal development for which I am further grateful to you all.

Thank you to the other of the 3 PhDs, what a journey.

Thanks to Drs. Tom Wilson, Barry Newell, Margaret Rossiter and Derek Roger for their invaluable comments on some of my thoughts.

To all my friends scattered across the globe; thank you for putting up with my ramblings and for keeping me sane.

Many thanks to all the people who allowed me to interview them while they were in the midst of sorting through the chaos after the earthquakes. Thanks also to all the organisations and interviewees without whom it would not have been possible to come to these conclusions. Without their cooperation and help this research would not have been.

To my family for putting up with my being in places that made you lose sleep at night: naonga.

To mum who made me believe that I could scale any heights and whose advice is even more useful today, I know you would have been so proud of me.

Abstract

The Canterbury region of New Zealand experienced four earthquakes greater than M_W 6.0 between September 2010 and December 2011. This study employs system dynamics as well as hazard, recovery and organisational literature and brings together data collected via surveys, case studies and interviews with organisations affected by the earthquakes. This is to show how systemic interactions and interdependencies within and between industry and geographic sectors affect their recovery post-disaster. The industry sectors in the study are: *construction* for its role in the rebuild, *information and communication technology* which is a regional high-growth industry, *trucking* for logistics, *critical infrastructure*, *fast moving consumer goods* (e.g. supermarkets) and *hospitality* to track recovery through non-discretionary and discretionary spend respectively. Also in the study are three urban centres including the region's largest Central Business District, which has been inaccessible since the earthquake of 22 February 2011 to the time of writing in February 2013.

This work also highlights how earthquake effects propagated between sectors and how sectors collaborated to mitigate difficulties such as product demand instability. Other interacting factors are identified that influence the recovery trajectories of the different industry sectors. These are resource availability, insurance payments, aid from central government, and timely and quality recovery information.

This work demonstrates that in recovering from disaster it is crucial for organisations to identify what interacting factors could affect their operations. Also of importance are efforts to reduce the organisation's vulnerability and increase their resilience to future crises and in day-to-day operations.

Lastly, the multi-disciplinary approach to understanding the recovery and resilience of organisations and industry sectors after disaster, leads to a better understanding of effects as well as more effective recovery policy.

Abbreviations

BRT (BRT-53) – Benchmark Resilience Tool (complete version)

BRT-13 - Benchmark Resilience Tool (short version)

CAS – Complex Adaptive Systems

CBD – Central Business District

CCC – Christchurch City Council

CCDU – Central City Development Unit

CERA – Canterbury Earthquake Recovery Authority

CDEM – Civil Defence and Emergency Management

CLD – Causal Loop Diagram

CREDS – Canterbury Regional Economic Development Strategy

ECan – Environment Canterbury

EQC – Earthquake Commission

FMCG – Fast Moving Consumer Goods

ICT – Information and Communication Technology

MCDEM – Ministry of Civil Defence and Emergency Management

MMI – Modified Mercalli Intensity (depicting severity of shaking in an earthquake)

M_W – Moment Magnitude (measuring the amount of energy released by an earthquake)

REAG – Resilience Expert Advisory Group

RRC – Recovery Rate Coefficient

SD – System Dynamics

TISN – Trusted Information Sharing Network

Definitions used in this thesis

Business-as-usual – organisational and sectoral conditions pre-earthquakes

Contextual interviews – interviews with industry and business leaders, recovery agency representatives to establish the background and context in which organisational and sectoral recovery was taking place after the Canterbury earthquakes of 2010 – 2011

Effective - the intended and actual outcomes are the same

Failure - when a system component does not fulfil its intended purpose in a certain timeframe (Leveson, 1986, p. 128)

Industry sector (sector) - a group of organisations that operate in the same segment of the economy or share a similar business type are characterised as making up an industry sector

Organisation - collections of people joining together in some formal association in order to achieve group or individual objectives (Dawson, 1992, p. xviii). Organisations in this study include for-profits, not-for-profits and government departments. Organisation and business will be used interchangeably in this thesis

Organisational crisis - threat to the organization's reputation and viability (Pearson & Mitroff, 1993, p. 49)

Organisational crisis management - the efforts by an organisation and external parties to prevent crises or to manage effectively crises that arise

Organisational or sectoral recovery - when an organisation or sector can function and sustain itself (continually) in its new post-disaster environment

Organisational resilience - the ability to survive crisis and thrive in a world of uncertainty Seville et al (2008, p. 18)

Risk - the effect of uncertainty on objectives - positive and/or negative (AS/NZS ISO 31000:2009, p. 1)

Societal crisis - a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR, 2009a, p. n. pag)

Supply web – a supply chain implies a linear relationship between a focal organisation, suppliers, customers and infrastructure used to manufacture/produce and deliver goods and services. From a system dynamics point of view, the interactions between these system actors is non-linear, hence the idea of the supply web.

System - an assemblage or combination of things or parts forming a complex or unitary whole (R. A. Johnson, Kast, & Rosenzweig, 1964, p. 367)

System delays and environmental time delays - a system delay is caused by a lag in the effect of one system element on another. In the time horizon for this thesis, the system delays are not yet evident. Environmental time delays are those in the system's environment that have an effect on the system.

Table of contents

Table of tables

Table of figures

1 Introduction

This study, using a system dynamics point of view, aims to close a gap in the disaster literature by investigating the recovery of industry and geographic sectors after the Canterbury series of earthquakes. A system is defined as an *assemblage or combination of things or parts forming a complex or unitary whole (R. A. Johnson et al., 1964)*. This means that industry sectors are systems within larger systems. Additionally, every system is defined for a purpose and is influenced by and influences its environment. The system dynamics approach makes use of qualitative and quantitative information in the generation of frameworks or models for the analysis of complex situations involving multiple agents. In this thesis, the use of system dynamics is advantageous because of the myriad interactions between the sectors and their environments and employs a holistic rather than reductionist approach.

In the last few years, not only has the trend of disasters increased, but the costs of these disasters have also been substantial. Natural disasters occur because of the interaction between humans and the environment (Dynes, 1974; Godschalk, 2003). New Zealand serves as an example of this interaction as a large majority of the population and the organisations based in the country are exposed to numerous natural hazards. On 4 September 2010, Canterbury in New Zealand experienced a M_W 7.1 earthquake. This was followed by three earthquakes greater than M_W 6.0. One of these was the 22 February 2011 earthquake which was more destructive in the widespread damage it caused, including the loss of 185 lives. Eighteen months after the 22 February 2011 earthquake, large parts of the Central Business District (CBD) of Christchurch, New Zealand's second largest city, remained cordoned off[1]. Organisations and industry sectors in the region are therefore faced with a complex, ever changing recovery scenario.

1.1 Canterbury and Christchurch

Christchurch is officially the oldest city in New Zealand. It is located on the east coast of New Zealand's South Island in the region of Canterbury. The essence of Christchurch is that it is the hub of the South Island of New Zealand (Korsching & Allen, 2004). At the time of the 4

[1] Progress for the gradual reduction of the cordon can be found at http://cera.govt.nz/maps/cordon-reduction, accessed 15 June 2012.

September 2010 earthquake, greater Christchurch's[2] population was approximately 400,000 people.

The Canterbury region is a significant part of the New Zealand economy (Canterbury Economic Development Co. Ltd., 2009). Half of all South Island businesses, accounting for 53 per cent of South Island employees, are located in Canterbury (Statistics New Zealand, 2011a). The geography of New Zealand's two main islands makes it prudent for many organisations to have a main base on each island. One of the major reasons for this is the cost of transporting goods between the two islands. Consequently, Christchurch's geographic position and its port facilities (air and sea) make it attractive to organisations. Its setting close to natural attractions such as mountains and the sea also makes it ideal for settlement.

1.2 Brief history of seismic risk and activity in New Zealand

New Zealand is located on the Pacific Ring of Fire; this is an extensive belt of volcanic and earthquake activity. This causes approximately 2500 earthquakes a year in and around New Zealand, most of which are too small to be felt.

> *"New Zealand is on the boundary between two [tectonic] plates; the Australian Plate and the Pacific Plate. These plates are constantly grinding into each other, which causes stresses to build up in the brittle, upper layers of the plates. When the brittle rock finally breaks, it generates an earthquake"* (Geonet, 2010).

Aside from ground motion, earthquakes can also cause the generation of tsunamis as well as liquefaction[3]. Since the European settlement of New Zealand, the largest earthquake on record was of M_W 8.2 on 23 January 1855 near the Wairarapa plains of the North Island. However, on 1

[2] Greater Christchurch has been defined by 'drawing a line around Christchurch City that takes in the communities within the 'commuter belt' (approximately half an hour drive from the Central City) in Selwyn and Waimakariri Districts. Greater Christchurch therefore includes the urban area of Christchurch City and Lyttelton harbour, the area of Selwyn District north of the Selwyn River and east of Kirwee (including the towns of Prebbleton, Lincoln, Rolleston and West Melton), and Waimakariri District south of the Ashley River and east of Swannanoa (including the towns of Rangiora, Waikuku, Woodend/Pegasus and Kaiapoi)' (The Greater Christchurch Urban Development Strategy, 2012)

[3] Liquefaction is defined as the transformation of a granular material from a solid to a liquefied state as a consequence of increased pore-water pressure and reduced effective stress (Laplante, 2007). The loss of effective confining stress within the soil results in an associated loss of strength and stiffness that contributes to deformations of the soil deposit (Goldratt & Cox, 1989). Cubrinovski et al (2002)note that it can occur during earthquakes.

September 1888, an earthquake with an estimated M_W 7.0–7.3 struck the Amuri district of North Canterbury, approximately 100 kilometres north-west of Christchurch. This earthquake caused damage to buildings over a wide area, including in Christchurch. Another destructive earthquake, M_W 7.8, struck on New Zealand's North Island near Hawke's Bay on 3 February 1931 and affected the towns of Napier and Hastings. The Hawke's Bay earthquake was New Zealand's deadliest with the loss of at least 256 lives (Khatri & D'Netto, 1995). It should be noted that New Zealand has experienced many large earthquakes, only some are mentioned here.

1.3 The Canterbury series of earthquakes

Historically Christchurch was thought to have a moderate seismic risk and the faults that caused the 4 September 2010 and 22 February 2011 earthquakes were previously unknown (Beavan, Fielding, Motagh, Samsonov, & Donnelly, 2011). However, that the 2010 – 2011 earthquakes occurred and caused such damage and disruption shows that organisations should have plans that encompass an extensive range of hazards.

1.3.1 4 September 2010 earthquake

The 4 September 2010 Darfield earthquake was a M_W 7.1 which struck the South Island of New Zealand at 4:35 am on 4 September 2010 local time. The earthquake caused widespread damage and several power outages. Mass fatalities were avoided partly due to the earthquake occurring during the night when most people were asleep. The earthquake's epicentre was 40 kilometres west of Christchurch, near the town of Darfield. The initial shaking lasted approximately 40 seconds, and was felt widely across the South Island. Initial claims after the earthquake, for damage to residential land, buildings and contents, were estimated to be between NZD 2.75 and 3.5 billion (Earthquake Commission, 2011).

1.3.2 22 February 2011 earthquake

The 22 February 2011 Christchurch earthquake, nearly six months after the M_W 7.1 earthquake of 4 September 2010, severely damaged Christchurch and caused the deaths of 185 people. The M_W 6.3 earthquake struck the Canterbury region at 12:51 pm on Tuesday 22 February 2011. The earthquake was centred approximately 5 kilometres west of the town of Lyttelton and 10

kilometres south-east of the centre of Christchurch. The February earthquake had some of the largest vertical peak ground acceleration (PGA) values ever recorded (Bradley, 2012).

The damage caused by the 22 February earthquake was especially pronounced in the Christchurch Central Business District (CBD) and the city's eastern suburbs. Some of the damage was exacerbated by buildings and infrastructure already being weakened by the 4 September 2010 earthquake and aftershocks. The total cost to insurers of rebuilding was estimated at NZD 20–30 billion, making it by far New Zealand's costliest natural disaster, and one of the costliest worldwide in 2011 (Swiss Re, 2011). A representative from the Canterbury Employers' Chamber of Commerce (CECC) pointed out that these estimated figures will likely rise as the scale of the earthquakes and effects become clearer (P. Townsend, personal communication, October 19 2011).

1.3.3 13 June 2011 earthquakes

On 13 June 2011 two more earthquakes, measuring M_W 5.6 and M_W 6.3, occurred in the greater Christchurch area. The earthquakes were centred approximately 10 kilometres from Christchurch. They produced severe shaking in and around the city of Christchurch, destroying buildings and causing additional damage to some of the structures affected by previous earthquakes. Rebuilding costs in Christchurch increased by NZD 6 billion owing to the additional damage from the 13 June earthquakes (Earthquake Commission, 2011). As at October 2012, the earthquakes in Canterbury are ongoing.

1.4 The disaster management cycle

The disaster management cycle comprises four main phases: reduction, readiness, response and recovery (O'Brien, O'Keefe, Gadema, & Swords, 2010). According to the United Nations Office for Disaster Risk Reduction, UNISDR, (2009b), there are two main phases after disaster: (1) response and (2) recovery. Response is immediate, involves rescue and also the restoration of essential services. Recovery is the phase in which the immediate needs of the affected community have been met and is the stage where the affected community seeks to return to what is normal. Consequently, recovery *involves compressing decades of development into a few years while reducing future risks* (Levers & Bhatia, 2011, p. 5). However, as Smith and Wenger (2007) also write, it is difficult to pinpoint when response ends and recovery begins as some activities

overlap in the two phases. The New Zealand Ministry of Civil Defence and Emergency Management (MCDEM) (2000) defines three aspects in the timeline for recovery after disaster: short-term (1-2 years), medium-term (2-4 years) and long-term (5 or more years). For the purposes of this thesis, the primary periods of scrutiny have been defined as:

→ response; and

→ short-term recovery.

There are two principal reasons for this. The first is that data were collected within the two year post-disaster window defined by MCDEM as short-term recovery. The second reason is that with each aftershock in Canterbury the response clock was reset and transition to recovery was made difficult.

1.5 Sectoral and organisational disaster resilience and recovery

In the disaster literature, there have been some studies done on the resilience and recovery of individual organisations[4] post-disaster. Other studies had documented the effects of disaster at the aggregated level of regions or nations. In addition, the effects of disaster are usually reported as damage or loss to the built environment. However, assessment of losses should also encompass those brought about by indirect means such as business interruption or loss of custom. Words such as *rebuild, restore* and *repair* have all been used in the discussion on recovery from disaster. However, the use of these words serves to simplify this often difficult, complex and drawn out task. Also, these words may disguise the realisation that after disaster, there may be irrevocable change (tangible and intangible) and that there is no return to what was.

Industry and geographic sectors[5] are the building blocks of any economy and are themselves made up of organisations. Furthermore, most national and regional economic plans are reported at the sectoral level and investment decisions are arrived at after analysis of sectoral trends. However, few disaster studies have focused specifically on the recovery of multiple industry and

[4] *Organisations* in this study include for-profits, not-for-profits and government departments. *Organisation* and *business* will be used interchangeably in this thesis.

[5] In this thesis, a group of organisations that operate in the same segment of the economy or share a similar business type are characterised as making up an industry sector. Sector and industry sector will be used interchangeably.

geographic sectors post-disaster: how they are affected and how they recover. The consequences of a disaster event to organisations are often complex, the causes difficult to unravel and effects can be long-lasting. As a result of the myriad interacting components, the effects of disaster are different for different industry sectors.

In relation to the Canterbury earthquakes, some of the questions that will be addressed in this thesis include: how are sectors affected by disaster?; how do sectors interact with each other in disaster?; what elements determine the degree of impact?; how long before organisations and sectors return to pre-disaster levels of performance?; and what are some measures that mitigated the effects of the earthquakes?

1.6 The Resilient Organisations research programme

The Resilient Organisations research programme aims to improve the resilience of New Zealand organisations to major hazard events. According to Resilient Organisations (2011), some of its strategic objectives include:

→ To better understand the nature of resilience within individual organisations and across sectors, and to communicate solutions for improving resilience

→ To develop tools and techniques that are easy to use for organisations to actively engage with the concept of resilience and to identify ways that they can improve their resilience

→ To build up a suite of case study examples of different resilience strategies that demonstrates how they can be employed at organisational, sectoral and community levels.

→ To continue undertaking longitudinal studies of the organisational aspects of post-disaster reconstruction and recovery to develop a significant body of knowledge in this area.

→ To continue to develop the business case for greater resilience by undertaking longitudinal studies exploring the linkages between resilience for crises with organisational performance.

The contributions resulting from this PhD will be to all of the strategic objectives listed and in particular: will investigate how and what disaster resilience strategies can be used at the organisation and the sector level; will chart recovery and reconstruction efforts after disaster and will enhance the already existing Benchmark Resilience Tool (BRT) (Resilient Organisations, 2010a).

1.7 Thesis arrangement

The emphasis in this work is on the system dynamics of organisational and sectoral recovery after the earthquakes in Canterbury. This thesis has 11 chapters that can be loosely broken down into three segments. The first segment (chapters 1 – 3) lays the foundation for this work, analyses the existing literature on organisations, crisis management and disasters and details the methods used for data capture and analysis. Segment 2 (chapters 4 - 6) presents the results from the data collection. These qualitative and quantitative results are then used in segment three (chapters 7 - 11) of the thesis where some statistical and system dynamics analysis is employed to investigate the key elements that affected the recovery of organisations and sectors in Canterbury after the 2010 - 2011 earthquakes. The contents of each chapter are detailed below.

Chapter 1 – Introduction

This chapter puts forward the reasons for the necessity of this body of work. It also outlines the context of the thesis.

Chapter 2 – Literature review

This section contains an exploration of the relevant literature that forms part of the discussion on organisational and sectoral recovery and resilience after disaster. This includes the literature on organisational crisis management and recovery, disaster recovery, system dynamics and disaster resilience.

Chapter 3 – Research methods and design

In chapter 3, the structure of the study is outlined. The plan for data collection and analysis is also presented. The justification for the methods employed in this study, how they are used

together and the sampling technique are explained. As well, the sample used in the study is introduced.

Chapter 4 – Contextual interviews

This chapter contains information from contextual interviews with industry representatives, business leaders and experts from recovery agencies. It contextualises and gives more detail of the sectors in the study as well as forming part of the background for the work that is presented in the later analysis chapters.

Chapter 5 – Surveys

Here results from the surveys deployed in the course of the research are outlined along with an interpretation for each set of results. The survey results are presented in two parts; the first part has the impact data and the second part has organisational resilience data. A comparison of the results from all three surveys is also done in this chapter.

Chapter 6 – Case studies

Chapter 6 has material from case study organisations that are a subset of the larger sample group. The case studies allow for a first-hand account from earthquake affected organisations and provide in-depth knowledge that adds to and complements the survey results in Chapter 5 and the contextual interviews in chapter 4.

Chapter 7 – Significant contributors to organisational and sectoral short-term recovery

In this chapter are discussed the major contributors to the recovery of organisations and sectors after the Canterbury earthquakes; considering the timeframe of data collection specifically the short-term recovery of organisations and sectors. The qualitative data from chapters 4 and 6 as well as the quantitative data from chapter 5 are first brought together in this chapter and used to determine the main contributors and signifiers to organisational and sectoral short-term disaster recovery. Statistical analysis methods are used in chapter 7.

Chapter 8 – System dynamics of organisational and sectoral resilience

In this section, information from chapters 4 to 7 is used in a system dynamics framework to show the interactions between sectors and other system agents. The system dynamics structure is used to explain the interlinked nature of recovery for the sectors and organisations in this

study and how this influences their recovery. Investigation of the system leads to the description of particular system behaviours and characteristics that have a bearing on organisational and sectoral recovery.

Chapter 9 – Points of leverage

Chapter 9 is an amalgamation of analysis of the system in chapter 8 and the data from chapters 4 to 7 to demonstrate the aids, hindrances and possible points of intervention in the system in order to effect recovery. This is an examination of the primary aids, hindrances and points of intervention to organisational and sectoral recovery in the context of the 2010 - 2011 Canterbury earthquakes.

Chapter 10 – Organisational disaster resilience

This chapter explains the need for both business-as-usual organisational resilience and organisational disaster resilience. The findings in this chapter are arrived at by analysis of the results from the Benchmark Resilience Tool (BRT-53) presented in chapter 5 (surveys) as well as the contextual interview (chapter 4) and case study (chapter 6) data. This is supported by the findings from the analysis chapters 7 – 9. Chapter 10 also has information on the self-report organisational disaster resilience indicators from organisations in the study, how the Benchmark Resilience Tool (BRT-53) can be improved and how organisations and by extension sectors can be more disaster resilient.

Chapter 11 – Summary and conclusions

This is the research summary and a brief discussion on the possible avenues of continuing the research in future.

1.8 Chapter summary

This chapter establishes the context of the thesis by giving an overview of the gap in the disaster recovery literature in analysis of industry sector recovery. This chapter also contains the rationale for the use of the system dynamics approach in investigating sectoral recovery after disaster. The myriad industry sectors and agents in the system necessitate the use of methods of analysis for complex situations.

As well, the chapter has information on the arrangement of the thesis with a brief description of the contents of each chapter.

The next chapter contains information on the state of the art in the organisational and sectoral disaster recovery field.

2 A review of the literature

The study of recovery after disaster is both inter- and multi-disciplinary. The topic brings together the subjects of risk, crisis, disaster, business, management, leadership, sociology, psychology, systems theory, complexity theory and engineering. This review provides an analytical, systematic review of the existing literature by breaking down and discussing the building blocks that make up part of the discussion on organisational recovery and that pertain to this thesis.

The review starts with an overview of what makes a disaster. This is followed by a section on the use of systems theory, complex adaptive systems (CASs) and how organisations fit in with these concepts. The next section has a definition of organisational recovery and organisational disaster resilience, which is followed by an analysis of organisations and risk as well as how crises develop and are managed in organisations. The discussion on crisis management includes organisational adaptability, innovation, learning and some possible barriers to preparation for crises.

The review then has a section on information currently available to do with organisational disaster recovery and the growing scholarship on the need for organisations to be disaster resilient. There is also a discussion on the general concept of organisational resilience. In the last part of the review, the context for this research is explained, along with the main aims and objectives.

It should be noted that the unit of analysis for this thesis is the industry or geographic sector. However, the data were collected through the sampling of the organisations within these sectors. As such, there is reference to both organisations and sectors because of this relationship.

2.1 Crisis, disaster and catastrophe

Disasters that can affect organisations can be of any description; natural (e.g. tsunami, earthquake, floods) or man-made (data loss, arson, oil spill). In the history of humanity disasters are not rare occurrences, neither is recovery from disaster. However, an important question that

should be posed when looking at risk, hazards, disasters and recovery is *when does a situation become a crisis or a disaster*? In answering the question, one view to take is that the definition depends on the point of view of the affected party (Dyson, 1983). Pearson and Mitroff define organisational crisis (or disaster) as an event that poses a

> *threat to the organization's reputation and viability (Pearson & Mitroff, 1993, p. 49).*

The United Nations International Strategy for Disaster Reduction, UNISDR, defines [societal] disaster as

> *a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources* (UNISDR, 2009a, p. n. pag).

This thesis is investigating sectoral recovery and resilience after the earthquakes in Canterbury. Consequently, both concepts of organisational and societal crisis are important. Furthermore, from the above definitions of crisis, it is clear that extreme events in and of themselves do not constitute a disaster; this comes about when a hazard event has destructive and damaging outcomes for organisations or for people. For instance, Bolin and Stanford (1998) in their analysis of an earthquake at Northridge in 1994 contend that disasters result when extreme events and human habitation come together. Others, such as Hewitt (1997) and Blaikie et al (1994) agree. Therefore, organisations and industry sectors, existing within larger systems, are affected by the interaction with other system agents and events such as earthquakes.

2.1.1 Different degrees of reach and consequences

The reported magnitude of hurricanes or earthquakes for instance does not in itself really communicate the scale of possible devastation. The aftereffects, to organisations, industry sectors and people, also vary according to the scale of the disaster event. Different kinds of disasters (for example caused by hurricanes, floods, earthquakes or tornadoes), bring different sets of problems and might require varied responses. Hurricanes for instance have some lead time before they make landfall. This is in contrast to earthquakes which give little, if any warning.

Quarantelli (2006) puts forward the argument that there are different levels of crisis and that it is important to differentiate them as this helps when it comes to the level or degree of response. Depending on the scale and societal impact of an accident or crisis, there can be an emergency, a disaster or a catastrophe.

2.2 Systems theory, systems thinking and systems practise

This thesis, in investigating how organisations can recover after disaster as well as how they can become more resilient to disaster, will be written from a systems perspective, i.e. by employing systems thinking. A reason for using systems thinking (sometimes called the *systems approach*) is to reflect more productively on how a system functions within a larger context (Gharajedaghi, 1999) and use that knowledge to improve the working of the system (Richmond, 1994). Systems theory and systems thinking are derived from General Systems Theory (GST) which was proposed by Ludwig von Bertalanffy in the 1930s (von Bertalanffy, 1972). Systems theory has made possible the growth of new ways of working on complicated problems that involve different disciplines and it gives a broader view of the workings of complex systems. Churchman (1979) writes that the true application of the systems approach calls for the working together of multiple disciplines.

A system is an *assemblage or combination of things or parts forming a complex or unitary whole* (R. A. Johnson et al., 1964, p. 367) and is how organisations and society are organised or structured (Ackoff, 1981; Haviland, Walrath, & El Prins, 2007). *Organised* indicates that these parts interact with each other by way of special relationships and that the system displays an overall behaviour unique to itself. The system is coherently organised in a way that achieves something; it has a function or a purpose (D. H. Meadows & Wright, 2008). The bi-directional information exchanges between the actors in a system leads to a process called emergence, where the system becomes a whole exhibiting properties not exhibited by its constituent parts acting alone.

A system is encircled by its environment and the (sometimes imperceptible but vital) separation between the two is the boundary. Any elements not in the system are in its environment (Sterman, 2000). It can be concluded that the system is defined based on its purpose and on the extent of analysis. The definition of what is included in a system is therefore subjective. However, because of each system having a purpose, it is important to add that a system's

environment is not and cannot be all elements not included in the system. The system's environment is specifically those elements that affect the system and are affected by it. This is vital in analysis of a system and is the view taken in this thesis. The system and its environment have a symbiotic relationship; they exchange input and output, both tangible and intangible. An example of a system is a community within the larger environment of a town. The purpose of the community is to serve the needs of its residents. The community is formed of many interconnected parts and the community's actions can influence the town and vice-versa.

Ackoff (1990) states that systemic thinking is holistic not reductionist and is synthetic not analytic. Reductionist and analytic thinking attempts to deduce the attributes of a whole by looking at that of its individual parts, i.e. not scrutinising the interconnectedness of the parts. Holistic and synthetic thinking deduces the attributes of components based on the whole that encapsulates them (Ackoff, 2004). This can be taken to mean that holistic thinking takes in the interactions between system agents and the emergent behaviour of the system. Embedded in the umbrella concept of systems thinking are different but compatible formal systems approaches. Some of the more well-known ones are shown in Figure 2-1.

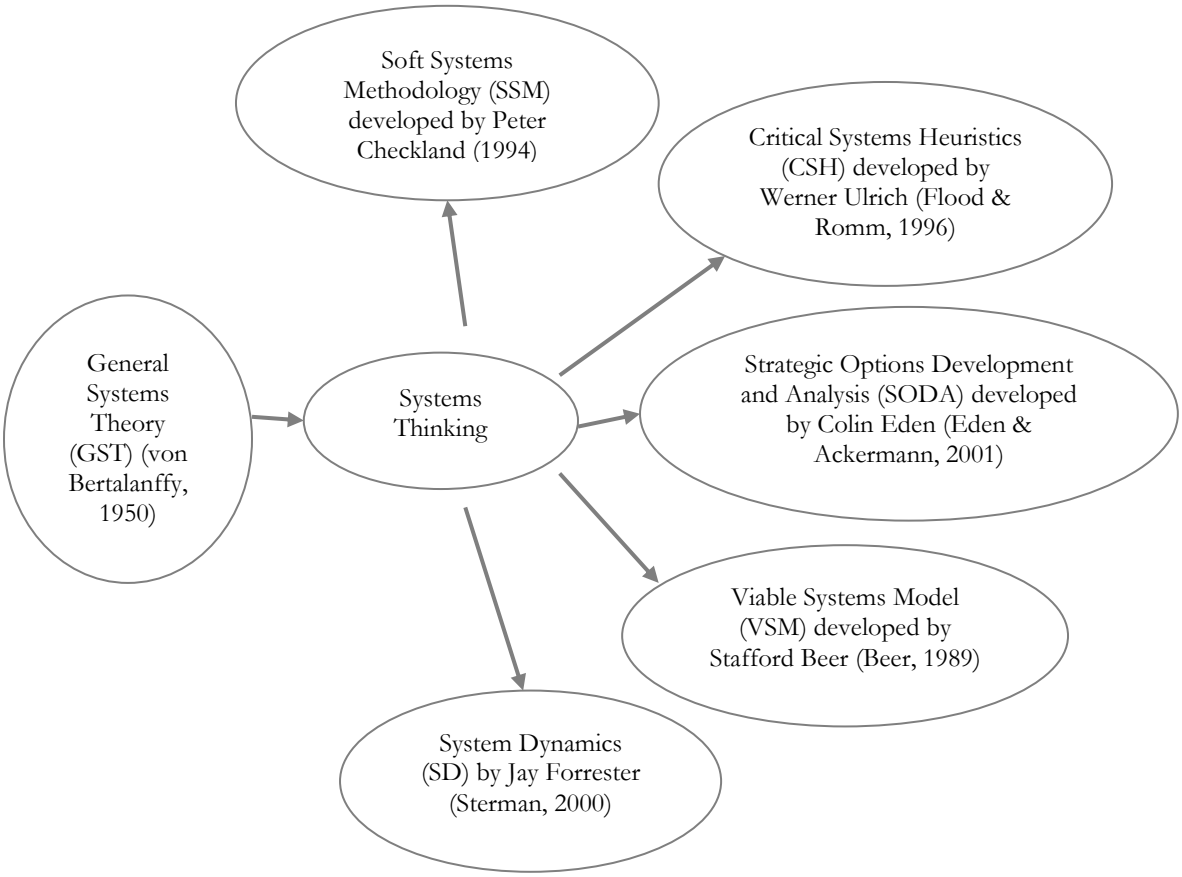


Figure 2-1: Different but compatible formal systems approaches

In this work, the approach used is that of system dynamics; which can be used to show how concerns that at first glance appear localised can have causes as well as outcomes that have a much broader impact. System dynamics is also used where there are multiple interdependent and interrelated components and helps to show that the solutions to complex problems are not simple and direct. System dynamics is built on three main concepts: the system, the structure of the system and the behaviour of the system. The structure of the system arises from the system components and the nature of the interactions among them. Consequently, behaviour of the system emerges from the structure of the system. Bateson (1972) emphasises that a fundamental point is recognition of the pattern of interactions between the elements in a system that gives rise to particular emergent behaviour. This perspective is useful for analysis of a complex disaster scenario such as that in Canterbury.

As observed, apart from being useful for looking at complex situations, system dynamics is useful for when they are dynamic. System dynamicists think in terms of two main classes of complexity. The first is combinatorial or detail complexity which is mainly in reference to the number of components there are in a system. The second is dynamic complexity which is a result of the exchanges between the components in the system over time and is possible even in what would be thought of as simple systems (Senge, 2006; Sterman, 2000). The types of complex problems examined through the lens of system dynamics are referred to as messes by Ackoff (1981). He further adds that the management of messes calls for planning and not [traditional] problem-solving which often looks for a linear cause and effect. Others such as Reynolds and Holwell agree with this perspective and add that messes for the most part have more serious ramifications, involve more people and *may appear in different guises* (Reynolds & Holwell, 2010, pp. 4 - 5).

However, systems theory and systems thinking should not be viewed as the mere simplification of complex problems. Manson (2001) asserts the same and argues that there is a possibility that interactions between actors can be erroneously viewed as having a one-to-one cause and effect relationship when this is not so as systems are non-linear. From Manson's description, this can be taken to mean that input and output do not always have a one-to-one relationship. For instance, a small amount of input could lead to a large amount of output and vice-versa. Dooley (1997) also takes this position. Sterman (2000) further describes the supply chain *beergame* which shows that a decision made at one point in the supply chain could lead to magnified effects in other nodes along the chain. The work of Johannessen (1998, p. 359) summarises the primary components to systems thinking:

- → the sub-systems and the system must be viewed in context, i.e. the part/whole relationship;
- → the system in the environment, not the system separated by a border is emphasised;
- → the type of connection between elements as this shows changes in the system; and
- → the reorganisation of the connection between elements as this provides guidance for processes of creation as well as innovation in the system.

The above points expressed alternatively can be thought of in terms of the five checks for a healthy system: balance, cohesion, clarity, completeness and consistency (Elms, 1998).

System dynamics can also be utilised to show the ways in which a system such as an organisation can protect itself and even benefit from internal and external disturbances which disrupt the workings of the system (Coyle, 1977). When the system can survive and thrive despite these disturbances, then the performance of the system is enhanced and can be said to be resilient.

2.2.1 Complex Adaptive Systems (CASs)

Holland (1992) notes that among systems of various types, there are those that when faced with disturbances in their environment have the capability to change and rearrange their component parts. He assigns to such systems the designation Complex Adaptive Systems (CASs). Apart from the ability to adapt, Holland states that CASs are also able, through the collective behaviour of their parts, to differentiate themselves from other systems. For example, an organisation, with its many interactions and ability to adapt is different from a static system such as a building. CASs can also anticipate changes in their surroundings. Lansing (2003) further notes that even what are considered the simplest systems can exhibit complexity, where complexity is seen as individual actors linked in a system and together exhibiting complex behaviour.

As pointed out earlier, organisations belong to larger, more complex systems such as industry sectors, communities and nations. Furthermore, in the literature organisations are considered social systems. Bunge (1985) writes that the study of social systems should comprise the study of four branches: biological, cultural, economic and political. However, it appears that physical systems are missing from Bunge's list. Interactions between physical systems and those defined by Bunge are vital in investigating recovery after earthquakes.

Additionally, Malotaux (2008, p. 1) writes that the study of systems should include understanding *both the interface and the behaviour of humans* so that people can work well within the system. Kelly (1995, p. 164) states clearly why organisations should be analysed as CASs:

> *The challenge is simply stated: Extend the company's internal network outward to include all those with whom the company interacts in the marketplace. Spin a grand web to include employees, suppliers, regulators, and customers; they all become part of your company's collective being.*

In CASs, the extent to which one part has an effect on another is known as the degree of coupling (Perrow, 1999). The extent of coupling can range from tight to loose. Another property

of a CAS relevant to this work is that it has memory; the system stores information from past events and can use that knowledge to inform its strategy in the present (Pentland & Reuter, 1994; Senge, 2006).

Authors such as Comfort (1999) and Shrivastava (1994) have shown that systems thinking is widely and successfully used in disaster research; while Senge and Sterman (1992) and Mitleton-Kelly (2003) show that it can be used to explain how organisations function. These two aspects will be used in this thesis to determine the key elements of organisational and sectoral recovery after disaster.

System feedback, hierarchy, self-organisation and resilience

The interactions between the actors or elements in a system are called feedback (Sterman, 2000). There are two types of feedback: positive (reinforcing) and negative (balancing). Positive feedback is where an action produces a result which leads to more of the same action whose outcome is growth or decline. Negative feedback is aimed at moving the system, through some action, to a current or desired state (the goal or the objective) (Sterman, 2000). As a result of positive and negative feedback, systems thinking includes a cyclical rather than linear pattern of cause and effect. Systems can also experience oscillation which is caused by negative feedback with time delays within the system. Also, one of the key features of positive feedback is that small distortions in the system can be amplified as they move through the system. Positive feedback is self-reinforcing and will continue until it reaches its limits or is counteracted by a negative feedback loop. For example amplification can be seen in a supply web when there is a variation in orders along the supply chain which can then lead to excess inventory in one part of the supply chain. Forrester called this the beer game (Sterman, 1989) (see section 2.5.2 for details).

Meadows and Wright (2008) and Sterman (2000) point out that there are three fundamental system characteristics that enable systems to function well: hierarchy, self-organisation and resilience. For this thesis, *function well* will be taken to mean that the system achieves its purpose. What can also be implied from these characteristics is that for hierarchy, self-organisation or resilience to occur, there must be an exchange of information or feedback among the system actors.

Organisations are systems within the larger system of an industry sector within a still larger system of an economy, a region or a nation. The nesting of systems within systems is known as the hierarchy of systems (Daellenbach, 1994) and makes the management of the system easier. Hierarchies (or subsystems) develop so that not all the system's information is contained in one subsystem; which might lead to an information overload. This is not to say that the right and relevant information should not be passed on to different subsystems. Importantly, the aim(s) of the subsystems should not be at cross-purposes to that of the overall system. However, there is the ideal system versus the real system. Therefore, it is possible that a subsystem is at odds with the larger system's purpose. This can lead to system sub-optimisation. In the system dynamics literature, it has been shown how in the functioning of a city, optimisation in one part without consideration of other parts can be detrimental (Helmreich, Klinect, & Wilhelm, 1999). However, another advantage of system hierarchy is that failure in one part of the system may not affect other parts. This is provided the failure is not so great as to cause system collapse and does not adversely affect other parts. This is the basis for Reason's Swiss Cheese Model of accidents (Reason, Hollnagel, & Paries, 2006).

System self-organisation is important because after a perturbation, the system can assume a temporary or permanent modified structure that enables the system to keep functioning. Self-organisation is also important for the continued existence of a system in a changing environment. Some of the organisational crisis literature points to the ability of a system, such as an organisation, to self-organise as a means of survival (Mitroff, Alpaslan, & Green, 2004; Senge, 1998).

Resilience, an emergent property of the system, is another term that is subjective (see section 2.7 for more detail). As has been demonstrated, resilience is not easy to measure (Manyena, 2006). Resilience contributes to the stability of a system through the feedback loops present in the system. There are various feedback loops in any system and these are dominant at different times. The existence of negative feedback loops leads to system balance or equilibrium. The resilience of a system is to ensure not just continued functioning of the system but also survival. This is achieved through the use of system feedback and the other system characteristics of hierarchy and self-organisation (see chapter 8.4).

System delays and environmental time delays

A system delay is caused by a lag in the effect of one element on another. In the time horizon for this thesis, the system delays are not yet evident. However, as is shown in chapters 6, 7 and 8, there are *time delays* in the system's environment and they affect the system. In Canterbury, some of these environmental time delays were to do with insurance settlement, availability of machinery, availability of skilled labour and decisions on building demolition. All these environmental time delays affected organisations and sectors.

2.2.2 System dynamics frameworks and modelling

The system dynamics approach makes use of system models for the analysis of situations and includes the use of quantitative and qualitative procedures. *Modelling* can be described as the construction of abstract models and includes the development of mental models, influence diagrams, causal-loop diagrams, stock-and-flow maps as well as stock-and-flow models (Adjunct Associate Professor Barry Newell, personal correspondence, 2012). Consequently, if the modelling (qualitative or quantitative) has to do with investigating the behaviour of a system over time, then this constitutes *system dynamics modelling* (Furlong & Scheberle, 1998; Hammer, Champy, Daniels, James, & Hughes, 1994; Handmer & Dovers, 1996; Markides & Williamson, 1994). Richardson and Pugh (1981, pp. 312-313) state that the use of a model as well as its effectiveness are dependent on the degree to which the model communicates, helps to generate insights, enhances understanding, and in general reaches and influences its audience.

Causal loop diagrams (CLDs) (see Figure 2-2) are mainly qualitative and help to show how interrelated variables (or nodes) affect one another. The relationships between these variables are represented by arrows and can have positive or negative polarity. For quantitative analysis of a system, stock and flow diagrams can be used. A stock is anything that accumulates or depletes over time while a flow is the rate of change of a stock. Figure 2-3 has a depiction of a simplified stock and flow diagram. *Inflow* adds to the stock while *outflow* depletes the stock. The arrows from *Stock* to *inflow* and *outflow* show that there is an exchange of information between the stock and the flows which can contribute to the rate of the flows. Notably, a stock is only ever changed through its flows. The clouds on the ends of the flow arrows depict the environment of the system.

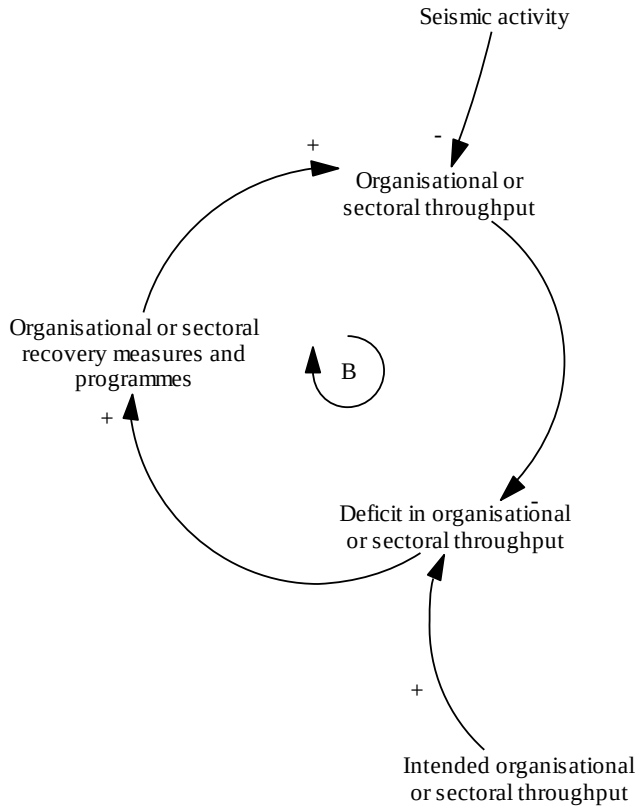


Figure 2-2: Illustration of a system dynamics causal loop diagram of organisational or sectoral recovery

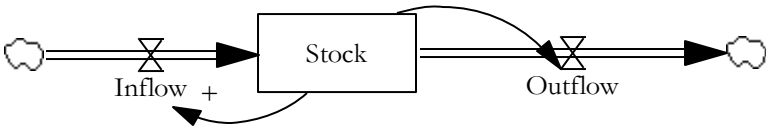


Figure 2-3: Illustration of a simplified system dynamics stock and flow diagram with inflow, outflow and information links

In system dynamics modelling, the time horizon in the model is crucial to analysis. The model must reach far enough into the past to show how a problem may have started as well as the symptoms and it should also go far enough into the future that it can show the delayed, indirect, unforeseen effects. This is very relevant to the discussion of recovery after crisis or disaster later in this work that posits that the pre-existing crisis or disaster conditions in an organisation may contribute to its recovery post-disaster. This is also relevant to the timing of data collection after a disaster, as will be seen in chapter 7.

The validation of system dynamics models is an important yet contentious subject. Even though system dynamics modelling uses both quantitative and qualitative information, some authors (Nordhaus, 1973; Zellner, 1980) have criticised the technique as relying too much on qualitative aspects. However, other authors such as Barlas (2006), Sterman (1984), Coyle (1977) and Forrester (1994) write that it is possible to validate system dynamics models. An alternative perspective on modelling in general is captured in the words of Box and Draper (1987, p. 74): *essentially, all models are wrong, but some models are useful*. In this thesis, the validity of the model has to do with how well it depicts the system being analysed, considering the system's purpose, as well as how useful the model is in analysing the system. Of utmost importance and with reference to any type of modelling; the usefulness of the model is dependent in the first place on the quality of the input information.

2.3 Organisational crisis management

Some authors (Tierney, 2007b; Turner, 1976) have noted that there are immense benefits to analysing the recovery of organisations after disaster from the point of view of the larger body of organisational research. This is to do with how organisations manage risk, cope in turbulent environments and in general handle run-of-the-mill crises. In this thesis, the study of organisational crisis management has been extended to how organisations deal with and recover from disaster. After all, a large proportion of the literature on crisis management is built on the evaluation of industrial or organisational disasters. Crisis management is defined as the efforts by an organisation and external parties to prevent crises or to manage effectively crises that arise (Pearson & Clair, 1998). The primary difference between a disaster situation and the day-to-day operations of an organisation is that the disaster environment compresses in time what would have occurred over a longer, more expansive timeframe (Olshansky, Johnson, & Topping, 2006). In disaster, decisions often have to be made under time pressure and tremendous uncertainty. For instance, when infrastructure is damaged after a disaster event, decisions have to be made quickly on the restoration, repair or replacement of this infrastructure and associated services. This is done in a shorter amount of time than a city would take to plan for and build infrastructure.

In this thesis, some of the concepts from the organisational (crisis) literature will be drawn on to investigate how organisations can recover from disaster. Some of these concepts include risk,

organisational decision making in crisis (Pearson & Mitroff, 1993), organisational processes (Clarke, 1991), organisational change (Dervitsiotis, 2003), leadership, organisational culture (Perrow, 1999; Senge, 2006), crisis management (Turner, 1976) and organisational resilience (Hamel & Välikangas, 2003; McManus, 2008; Stephenson, 2010). All of these works have looked at the organisation as composed of elements as well as the organisation in its environment. This is compatible with the systems approach adopted for this thesis.

2.3.1 Organisations and risk

The life-cycle and operation of any organisation involve risk. The Joint Australia New Zealand International Standard (AS/NZS), based on the International Standard Organisations ISO 31000:2009 document, defines risk as *the effect of uncertainty on objectives - positive and/or negative* (AS/NZS ISO 31000:2009, p. 1). From the literature on crisis and disaster management, Comfort (2005, p. 338) says risk *represents the possible occurrence of a harmful event that has some known likelihood of happening over time*.

A group of experts (Jolly, 2003) in the field of corporate risk write that effective risk management can be used as a tool for corporate survival. In the guide, the authors argue that for reasons such as population shift and technological advances, the risks faced by organisations are ever changing and that the management of risk should be a part of an organisation's everyday operation. The authors point out that the main areas of corporate risk can be broken down into financial (e.g. affecting capital), strategic (e.g. affecting the wider business environment) and operational (e.g. affecting organisational processes). The authors advise organisations to identify risks that may affect them, specifically how the organisation would be affected and lastly to prioritise these risks according to severity for the organisation.

Risk is therefore unavoidable. As well, other authors state that the organisation does, however, have the power to choose between risks and how to effectively identify, analyse and manage those risks (Couto, 1989; Kaplan & Garrick, 1981; Wildavsky, 1988). As with recovery and resilience, the definition of risk is subjective. For different organisations, different risks pose different threats. Thinking of ways in which the organisation would react given a certain risk also plays a part in how that risk is perceived and planned for. The analysis of risk should also include consideration of context: of the system as well as the scale. For instance, for risk

reduction, Comfort (2005; 2001) calls for the involvement of multiple actors such as government agencies, for-profit organisations, not-for-profits organisations and the community as they all form a part of a system.

2.3.2 **The inevitability of crises?**

In this thesis, *failure* is defined as when a system component does not fulfil its intended purpose in a certain timeframe (Leveson, 1986, p. 128). This can be the organisation or in one part of the organisation. There has been a need in both industry and academia to define failure; how and why accidents and crises develop; how they can be prevented, mitigated and managed; as well as what consequences could result.

There are a few noted schools of thought which at first seem incompatible but do have some similarities; these are High Reliability Theory (HRT) (La Porte & Consolini, 1991) and Normal Accident Theory (NAT) (Perrow, 1984). LaPorte and Consolini (1991), Roberts (1990) and Weick (1987), proponents of HRT, state that the design and working of the organisation itself contributes greatly to safety and to preventing accidents, in part by being proficient in reacting quickly to failure. On the other hand, the underlying premise of NAT is that regardless what measures organisations take, accidents will happen and chances increase with the level of system complexity (Perrow, 1994). There is general consensus that in complex systems, accidents happen when various factors coincide (Cook, 1998; Reason, 2000; Turner, 1976). For example, when *failsafe* mechanisms like emergency buttons, personnel training and procedures are in use at any one time, one of these failing might not lead to a catastrophe, but their combined failures and interactions could. This means that failure is dependent on the state of the system and on factors present and interacting at any given time. Leveson (2010) confims this notion.

Much has been said and written by the advocates of the two differing outlooks of NAT and HRT on organisational safety, the inevitability of accidents in organisations, how organisations can deal with cascading failure as well as how such analyses can be used to give insight into how organisations might be vulnerable to disaster. However, a point of view adopted in this thesis is expressed in the work of Leveson et al (2009) who write that although NAT and HRT have been discussed at length, they can still benefit from being integrated with the systems approach to problem analysis for organisations. NAT and HRT have limitations such as confined or

restricted definitions and the unclear difference between reliability and safety and would therefore be enhanced by the inclusion of systems thinking in the two theories.

Apart from NAT and HRT, there is what Mitroff terms *abnormal accidents* (Mitroff, 2004, p. 43) of the deliberate, intentional kind. In this category, one of the biggest events in recent living memory, and whose effects are still being felt, is the flying of planes into New York's twin towers in September 2001.

Additionally, Heinrich (1950) put forward his *Domino Theory* in which he asserts that metaphorically, an accident is like a line of dominoes falling over: the culmination of a chain of sequential events. When one of the dominoes falls, it knocks down the next one and so on (the domino effect).

Heinrich's (1950) five symbolic dominoes which may cause accidents:

- → social environment and ancestry;
- → fault of person;
- → unsafe act, mechanical or physical hazard (unsafe condition);
- → accident; and
- → injury (Heinrich et al., 1950).

However, removing a key factor such as an unsafe condition or an unsafe act prevents the start or the perpetuation of this chain reaction. Unsafe acts are those which are caused by persons not paying enough attention, and unsafe conditions might be a result of inadequately designed or improperly maintained equipment and work areas. Alternatively, the system could have built-in buffers to dampen the reaction.

What can be added to Heinrich's Domino Theory and relevant to this thesis is that either method should be designed with the entire system in mind. Another point of interest is that Heinrich points specifically to *fault of person*. Organisations are social systems; therefore it is of little value to design processes as if they were solely for use by machines without taking into account the human element. Reason (1998) has written on this. In other work, Malotaux (2008, p. 1) contends that *in practice we see however that many systems fail because engineers ignored, forgot to*

include, or incorrectly assumed how people interface and behave. Therefore, regarding accidents and failure prevention which can lead to crisis, it can be argued that *systems fail, not people* (Cook, 1998; Reason, 2000; Turner, 1976). In other words, failure is a property of the entire system and not of the individual components. Accordingly, Pugsley (1973) , from the discipline of structural engineering, developed an indicator model that can be used by organisations in the assessment of risk and the potential occurrence of crisis or disaster. The indicators are:

- → new or unusual materials;
- → new or unusual methods of construction;
- → new or unusual types of structure;
- → experience and organisation of design and construction team;
- → research and development background;
- → industrial climate;
- → financial climate; and
- → political climate.

Both the Heinrich and Pugsley models can be extended and used in dealing with organisational crisis. First, they can both be taken as very general in how they define their indicators. Heinrich's model does not include specific environmental factors such as finance or politics that could trigger some of his dominoes. Pugsley's model, on the other hand, includes some environmental factors but he does not explicitly discuss the interaction of the indicators. This is where the use of system dynamics is essential in looking at the different elements in the system and how they are related to each other and could affect recovery. Using both Heinrich's and Pugsley's models, organisations could adapt them to different situations and add missing elements relevant to the organisation's situation. Lastly, both models are qualitative which would make it difficult to observe any changes as well as the degree of those changes, in the system. Therefore, metrics are required to measure the indicators.

From the theories discussed in the above paragraphs, it is clear that trying to detail all the possible failure permutations is impossible; the world is filled with unknowns and a disaster in some form is bound to happen at some time. That such complex systems are built in the first place, leads to what Charles Perrow (1986, p. n. pag) calls the *habit of courting disaster*.

Consequently, as complex systems have more parts to them and differing degrees of interaction between those parts, component interaction accidents where the system designers did not plan for all the possible interactions are more common (Leveson, 2010). In the New Zealand context, Isaac (1997) shows how pre-existing organisational conditions in the Department of Conservation and local conditions in the creation of a viewing platform led to disaster. Pre-existing organisational conditions included understaffing leading to overworked staff while local conditions were a poorly designed and constructed structure.

For organisations, it is therefore prudent to take the all-hazards approach which requires the development of organisational plans and responses capable of dealing with a wide range of disruptive activities as opposed to a few targeted ones. This idea of the all hazards approach has been documented in the disaster and emergency management literature (Berkes, 2007; Godschalk & Brower, 1985; New Zealand Ministry of Civil Defence and Emergency Management, 2012b; Reason, 2000; S. D. Smith, 2004). There is also a need for organisations to become more resilient in the face of numerous crises (Hamel & Välikangas, 2003).

Lastly, it has been shown in the organisational crisis literature that failure to identify risks or the mismanagement of risk and crises could have negative consequences for the organisation. For instance, Pretty and Knight (2002) show how an organisation's misidentification of risks and mismanagement of crises can result in the loss of value of the organisation's stock price.

2.3.3 The build-up and progression of crises in organisations

Various models for how organisational crises develop have been suggested. One model, proposed by Turner, refers to the *failure of foresight* (Turner, 1976, p. 378) and is shown in Table 2-1. This is where facts to pre-warn of a crisis were available but there was failure to act on this information to prevent or mitigate the crisis. One of the most crucial of the stages in Table 2-1 is the second stage, which from a systems viewpoint outlines an emergent property of the system: from the pre-conditions as separate parts to the emergent state of disaster (or accident).

Table 2-1: The sequence of events associated with a failure of foresight

The sequence of events associated with a failure of foresight	
Stage 1	Notionally normal starting point: (a) Initial culturally accepted beliefs about the world and its hazards (b) Associated precautionary norms set out in laws, codes of practice, mores, and folkways
Stage 2	Incubation period: The accumulation of an unnoticed set of events which are at odds with the accepted beliefs about hazards and the norms for their avoidance
Stage 3	Precipitating event: Forces itself to the attention and transforms general perceptions of stage 2
Stage 4	Onset: The immediate consequences of the collapse of cultural precautions become apparent
Stage 5	Rescue and salvage – first stage adjustment: The immediate post-collapse situation is recognised in ad hoc adjustments which permit the work of rescue and salvage to be started
Stage 6	Full cultural readjustment: An inquiry or assessment is carried out, and beliefs and precautionary norms are adjusted to fit the newly gained understanding of the world

Adapted from (Turner, 1976, p. 381)

Another model detailing how crises develop and are handled was proposed by Smith. This model has three main phases: *crisis of management, operational crisis situation and crisis of legitimation* (D. Smith, 1990, p. 271). In phase one, there is failure to use the information presented by a situation that is imminent and demonstrates the role of management in the unfolding of organisational crises. Phase 2, the operational crisis situation (sometimes called the response phase), is where the crisis is manifest and the organisation moves into crisis mode to try to address the crisis. Recovery is part of the final crisis of legitimation phase of Smith's model. This is also the phase in which organisations try to deal with and adapt to the changed environment, and also where they look for whom or what might be to blame for the crisis.

It appears that in Smith's model, resilience is measured by the kind of information available, how it is used, as well as the organisational learning and culture. Furthermore, the models by Turner[6] and Smith use different vocabulary but are very similar. Phase one in Smith's model corresponds to the first two stages in Turner's model. Smith's response phase is similar to Turner's stages 3 and 4, while Smith's phase three aligns with Turner's last two stages. From the two models discussed, it can also be concluded that other than planning, how a crisis is handled can itself lead to an escalation of the crisis. How organisations react to an external event such as an earthquake is an example of this. Both Turner's and Smith's models appear to take the organisation in isolation. However, from the system perspective, there are environmental factors that may influence the development and progression of a crisis. Also from the system's

[6] This work has since been added to by Pidgeon.

perspective, the time horizon prior to the crisis and during the crisis should be considered. This has not been included in the models.

As well, the models put forward by Turner and Smith are to do with man-made disasters while this thesis deals with organisations affected by a disaster caused by earthquakes. However, some of the lessons from how organisations handle man-made disasters can be used to investigate how they deal with natural disasters. To start, organisations consist of people, who would be the ones dealing with a disaster regardless of the cause. Also, as organisations are part of larger systems, they are likely to be affected through their assets, staff, processes, customers or supply chain for example, by a regional disaster. Lastly, it is possible that a natural disaster could exacerbate existing or potential problems in an organisation. This is equivalent to the second, incubation, stage in Turner's model.

In addition, dealing with crises requires some prior, effective planning (Quarantelli, 1988). The assumption is often made that if disaster preparation has taken place then the management of crisis will be an automatic success. Instead of waiting for an event to occur to gain experience, organisations could instead use simulated exercises where all the major actors are present as a way of checking for gaps, testing the system and fine-tuning it. For instance, Clarke (2001) cautions organisations against thinking that written plans alone are sufficient. As well, apart from the documents written by organisations for their own use, there are numerous standards that detail how an organisation should behave in a certain situation. Again, the compliance with such standards does not always translate into how well the organisation will do in a crisis.

Lastly, MacManus (2008) writes that in planning to manage crises, organisations should understand what hazards they face and how they might be affected by them. Depending on scope and extent, hazards with the potential to affect an organisation can be categorised as:

- → regional (such as the 2010 and 2011 Canterbury earthquakes to organisations based in the region);
- → societal (such as the SARS outbreak in 2003 affecting organisational staffing and manpower);
- → localised (organisation specific such as the BP Deepwater Horizon oil spill of 2010); or

→ distal (consequences as a result of actions on the supply chain for instance) (McManus, 2008).

In this thesis the primary focus is on disasters of a regional nature and to a small extent those that are distal.

2.4 Adaptation and learning

It has been argued that for a social system, such as an organisation, to recover from disaster a certain level or amount of adaptation and learning are necessary. Furthermore, in order for there to be adaptation and innovation, there needs to be learning (Hall, 1962). Consequently, learning and adaptation in a system are a result of the information exchanges within the system: of feedback.

2.4.1 Organisational adaptability

Pasmore (1994) argues that for organisations, two things are certain: the speed of meaningful change will increase and complexity will grow. Therefore, it can be concluded that organisations need to respond with more thought, better utilisation of resources and better organisational preparation. From a systems perspective, organisations should adapt and also evolve. This will enable organisations to handle successive change without resorting to *firefighting* where each crisis is handled singly with no planning for the future or experience from the last crisis. Managing one-off crises on a continually ad hoc basis is insufficient, inefficient and time-wasting (Pasmore, 1994; Senge & Sterman, 1992). Organisations should also be able to adapt to changing environmental factors and achieve their goals not only during business-as-usual but also through tumultuous times (Boisot & Child, 1999; Dervitsiotis, 2004; Hamel & Välikangas, 2003). Fink et al (1971) and Mitroff (2005) allude to the fact that crises can be a positive learning experience provided they do not cause the organisation permanent collapse. In fact, organisational resilience itself becomes a competitive advantage.

Also, for a lot of complex systems, Edmunds et al. argue that *problem formulation poses a difficult challenge and a highly flexible process is required to cope with the necessarily evolving configuration* (Edmunds, Feldman, Hicks, & Mullineux, 2010, p. 1). For organisations, *problem formulation* can be taken as the direction of organisational evolution and is made even more challenging in a crisis or

disaster situation. Edmunds et al further state that; *the objectives and constraints are not independent, so they have to be dealt with concurrently; additionally, they may evolve as the design process continues and understanding of the system develops, meaning that some objectives must be added, strengthened, weakened or removed completely* (Edmunds et al., 2010, p. 2). However, the organisation gains from going through this process by better understanding their operating environment and thereby ensuring that they can learn and adapt.

2.4.2 **Learning**

From the literature, organisations need to innovate, be diverse, adapt and keep learning in order to carry on being successful as well as handle crises effectively (Ferrier, Smith, & Grimm, 1999; Hamel & Välikangas, 2003; Lengnick-Hall & Beck, 2005; Pascale & Athos, 1981; Peters & Waterman, 1982; Senge, 2006; Stacey, 1995). Using the analogy of the organisation as a complex adaptive system (CAS); a CAS is resilient to disruptions from the environment that would cause the breakdown of less adaptive systems, and it does not need perfect conditions in which to exist (Holland, 1992; Levin, 1998). It can alter its own state to make up for variations in the environment, thereby increasing its ability to survive and even thrive. Furthermore, because it has memory, a complex adaptive system can learn to make the best of its situation and circumvent or deflect many hazards that may exist in its environment (Pascale & Athos, 1981; Senge, 2006). As a result of CASs being dynamic and non-linear, there are a number of factors which could combine to give a different outcome every time and at no two points in time are the states of the system identical (Dooley, 1997; Holland, 1992). Using the conditional probabilities view of the Markov process[7], a system's ability to withstand crisis or disaster in one state is a measure of the likelihood (probability) of its transition to a different state (Belegundu & Chandrupatla, 1999). The ability to withstand should not be taken to mean that the system does not change as that may mean that the system is not adaptable. The inability to adapt could itself lead to failure.

Pascale and Athos (1981) as well as Senge (2006) describe how finding an organisation's best fit, given the environment, and deciding what direction to take are a part of organisational learning. This is because factors like customers, competitor behaviour and other events over which

[7] The Markov Process is sometimes used in the optimisation of systems in systems engineering

organisations do not have complete control, all have the ability to affect an organisation. However, using information from the environment, organisations can adapt and create an environment in which the organisation can continuously learn and operate. For example, Thomke et al (1998) found that two-thirds of equipment innovations in the semi-conductor industry were developed by the end-user feeding information back to organisations.

The environmental feedback affecting the organisation's strategy formulation also necessitates that organisations plan ahead while at the same time being ready for change. However, organisations find that they have to make decisions with only the information at hand, what Herbert Simon (1991, p. 132) refers to as *bounded rationality*. According to Dovers and Handmer (1992, p. 270), for organisations *recognition that additional knowledge will not by itself provide all, or even the main, answers, means that in effect we have to learn how to manage in ignorance*.

Additionally, limited and intangible resources such as money, time, competence and market share act as constraints on the decisions an organisation can make, which in turn has a bearing on organisational strategy. Resources can be even scarcer in a disaster environment; a situation which can be amplified when multiple actors are competing for the same resources. As a result of operating under changing multiple constraints especially in crisis times, occasionally, any CAS moves towards a *critical* state (Bak, Tang, & Wiesenfeld, 1988, p. 364) where the system is at the edge of transition between two states. It is in this critical state, what Dervitsiotis (2003, p. 252) calls the *edge of chaos*, that conditions are ideal (for the system's purpose) and organisations have the best opportunity to make dramatic change. Even as an organisation has to deal with finding its best fit under multiple constraints, the major developmental changes, the critical states, occur intermittently (Sneppen, Bak, Flyvbjerg, & Jensen, 1995).

Lastly, organisations need to remember that *long periods of success [can] breed complacency* (Hopkins, 2007, p. 7). In certain instances, organisations should forget what made their enterprise successful previously as this might lead to failure of a new venture (Hamel & Välikangas, 2003). The process of innovation and creation should be treated as an opportunity to learn as failure in itself is not a bad thing; it is what is learnt in the process that is important (Cannon & Edmondson, 2005; Senge, Scharmer, & Flowers, 2005).

Individual learning

One aspect of better crisis management is the ability of the organisation to learn. In thinking of organisations as systems, one of the most important components of that system is the people who make up the organisation (Kaplan & Norton, 2004b). A discussion on organisational learning would be incomplete without mention of individual learning. It can be deduced that when an individual learns, the organisation also learns. Kim (1996) writes that even though there does not exist a universal definition of organisational learning, the important thing is how individual learning is transferred to or incorporated in the organisation. Organisational crisis learning can be divided into 3 stages, all of which involve the human aspect:

- → pre- (prior personal experience, history);
- → intra- (lessons learnt during a crisis); and
- → post-crisis learning (feedback, debrief, commissions of enquiry) (Newlove, Stern, & Svedin, 2003; Stern, 1997).

Fundamentally, individuals should learn what is relevant for the purpose of the organisation and they should learn well. In a crisis situation, this is even more important, especially given the heightened uncertainty of the environment. It is argued that people are more motivated to bring about positive change when they feel they have a stake in the life of the organisation (Collins, 2001).

2.4.3 Possible impediments to preparation for crises

In the disaster literature, Mileti and Sorensen (1987) posit that the degree of damage wrought by disasters like earthquakes can be lessened if appropriate preparatory measures are taken prior to the disaster. For instance, Spittal et al (2005, 2008) in their findings from work on preparedness for earthquakes, report that optimistic bias may affect the preparation for hazard events. Optimistic bias (originally unrealistic optimism by Weinstein (1980)) is the inclination people have that negative actions are less likely to happen to them. This mindset could lead to inadequate planning and preparation for hazard events leading to catastrophic losses.

Additionally, Senge (2006) states that organisations maintain long-term memory and organisational culture through the processes and procedures they establish and practice in their

day-to-day operations. These ingrained organisational routines may have a bearing on how organisations manage disasters. For instance, when faced with a disaster event organisations might carry on with normal routines in trying to deal with the crisis when a response commensurate with the situation is called for (T. C. Powell, 1991). This is supported by Staw et al (1981, p. 507) who write that for some organisations, dealing with an extraordinary crisis situation such as that brought on by an earthquake may lead to a *maladaptive* reaction that threatens the organisation's survival, even when the same organisation is perfectly capable of handling other problems with which they are more familiar.

Even while organisations employ the all-hazards view in crisis preparation and mitigation, no two crises are identical and each crisis should be thought of as a learning experience (D Smith & Sipika, 1993). This is related to organisations learning continuously. Leveson (2010) suggests that organisations should take up new, more sophisticated, systemic methods for the analysis of failure as systems have become more complex. Depending on the scale of analysis, methods of problem solving which are built around cause and effect having a linear relationship, which is not the case with complex systems, (Leveson, 2010) should be avoided. Additionally, there are some hazards that are truly unique but should still be considered in planning. As the 2010 and 2011 Canterbury earthquakes and Hurricane Katrina in 2004 show, although it is known that a major event might happen, the effects caused by the event are difficult to predict in their entirety. Taleb (2007) writes about such events and calls them *Black Swans*; where humans are blind to and in denial of the fact that extreme events they have not thought of could occur. To cope with Black Swan events, Taleb advises that people and organisations should be built robustly to protect them against the negative type of Black Swan event while allowing them to take advantage of the positive type. Another impediment might involve the thinking that after surviving one disaster, organisations may think that they can survive the next one (Mitroff et al., 2004).

While there are some impediments to preparing for crisis and that it is not possible to be prepared for every scenario, some amount of preparation can ensure that the organisation has a starting point after a disaster occurs. For instance, in how to contact staff.

2.4.4 **Inter-organisational and inter-sectoral dependencies**

The environment of an organisation is made up of many entities. Nystrom and Starbuck (1981) advise that distinguishing organisations from their environments is not an easy task and may

distort the reality of the interactions among them. Evan (1965) typified a focal organisation and all actors that interact with it as an organisation set. In the organisation set, these interactions vary in their formality and frequency and can be co-operative, neutral or conflicting. For instance, an organisation may have frequent contact with its customers, co-operative interactions with suppliers and conflict with any elements that might disturb the organisation achieving its goals. Evan adds that some of these interactions are specific in extent and can be because of factors such as the organisation's location or industry sector.

Dawson (1992) explains that the interactions an organisation has can be put into three broad categories; interactions to do with the supply of inputs, interactions to do with distribution of output goods and services, and regulatory interactions of the organisation's operations and transactions.

Furthermore, in this thesis, a group of organisations that operate in the same segment of the economy or share a similar business type are characterised as making up a sector. *Sector* and *industry sector* will be used interchangeably in this thesis. As there are interactions and dependencies between organisations in the same or different sectors, it follows that there are interactions and dependencies between sectors also.

2.5 Recovery

Before investigating factors that contribute to recovery, there is a need to define the concept. Just as with the concepts of crisis, disaster or risk, recovery also has myriad definitions, dependent on the context of recovery under examination and to a lesser extent on academic discipline. The definition of recovery is important because the description of what recovery looks like and incorporates is an extension of the definition of the purpose of a system. From the disaster literature some of the definitions of recovery are shown in Table 2-2.

Table 2-2: Definitions of recovery from different research areas and disciplines

Definitions of recovery from different research areas and disciplines		
Author (s)	**Academic research/discipline**	**Definition of recovery**
Leveson	Computer Science	Backward recovery techniques involve returning the system to a prior state. Forward recovery involves repair of the faulty state (Leveson, 1986, p. 152)
Tierney	Sociology	Longer-term efforts to reconstruct and restore the disaster-stricken area, e.g., through repairing or replacing homes, businesses, public works, and other structures (Tierney, 1993b, p. 1)
Alesch et al	Urban and regional planning	In systems terms, recovery means a return to [a state of] dynamic homeostasis approximating conditions and relationships that existed before the event (Alesch & Holly, 2002, p. 2)
Altay and Green	Operations research	Recovery involves the actions taken in the long term after the immediate impact of the disaster has passed to stabilize the community and to restore some semblance of normalcy (Folke et al., 2004, p. 480)
Smith and Wenger	Sociology and social research	The process of restoring, rebuilding, and reshaping the physical, social, economic, and natural environment through pre-event planning and post-event actions (G. P. Smith & Wenger, 2007, p. 237)
UNISDR	Humanitarian/disaster reduction	The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors (UNISDR, 2009b)

It is clear from Table 2-2 that recovery is complex and encompasses many aspects. It has been argued that disasters are social phenomenon and should be considered in this wider social context; they should not be thought of merely as physical phenomenon (Dynes, 1974). The definitions in Table 2-2 have included some of the social aspects of disaster. From Table 2-1, the authors have used the words *restoration*, *reconstruction*, *rebuilding*, *repair* and *replacement* in describing some of the activities that could be involved in recovery. The conceptualisation of all these ideas as being part of recovery shows that the definition of what recovery is or what it involves depends on the lens of analysis. For instance, the definitions in Table 2-2 all point to there being a disruption to what is perceived as normal and that there is a desire to correct, or stabilise, this situation. Additionally, Smith and Wenger (2007) illustrate that recovery from disaster cannot and should not be separated from disaster preparedness and mitigation.

For the recovery of organisations and industry sectors in this thesis, their recovery should consider that they are systems nested within larger systems and that they are influenced by and influence the environment.

2.5.1 Sectoral and organisational recovery

It is the opinion of the author that recovery encompasses all of the ideas in Table 2-2 and is not about returning to how things were before a disaster eventuated. This is impossible as even in non-disaster circumstances, everything changes with time. Alesch at al., (2009) in looking at community recovery after different disasters attest to this. For the purposes of this thesis, recovery of an organisation[8] or sector is defined as

when an organisation or sector can function and sustain itself (continually) in its new post-disaster environment.

Recovery is also about setting the conditions where organisations can thrive, so not only rebuilding and recovering for the short-term but also about orienting the wider economic, social and political conditions of an area in order for organisations to prosper in the medium- to long-term. Additionally, organisations and sectors are affected in different ways by disaster; these effects (or impacts) can be direct or indirect and can be positive or negative.

2.5.2 Organisational recovery after disaster

With every disaster, it is evident that the losses that result are not instantaneous. Instead, they accrue over time. This is partly to do with systemic characteristics of non-linear cause and effect as well as delays (see chapter 8.4.2 for more detail on system delays and environmental time delays). Even more, the effects of disaster should be placed in context; organisations, industry sectors, people and places are not affected the same by disaster and the process of recovery can be long, complex and arduous.

With the increasing numbers and costs of disaster, there has been a lot of interest in recovery from various parties such as governments, local authorities, insurers and the disaster research community at large. However, after a review of the disaster literature, recovery (especially for response and short-term recovery) after disaster does not seem to have been rigorously examined and outlined. Quarantelli (1999) and Rubin (2009) propose that this is likely because the process of recovery is lengthy and complex and involves physical, social, political and

[8] Dawson (1992, p. xviii) defines organisations as *collections of people joining together in some formal association in order to achieve group or individual objectives*.

economic aspects. The involvement of these different aspects pointed out by Quarantelli and Rubin means that recovery is a systemic process and where systems analysis should be used. Alesch (2002) also advocates planning for recovery from a systems point of view. Further examination of the disaster literature shows that the process of recovery is without a clearly determinable point of completion. While this point is valid, it can be argued, that depending on the definition of recovery, i.e. aligned with the purpose of the system, it may be possible to recognise recovery at some point from a disaster event.

In the disaster and recovery literature, there are numerous studies that have analysed different aspects of recovery for organisations but this has been done in the context of the recovery of larger areas or economies. Losses from recovery have traditionally also been looked at from the household or regional level. However these aggregated loss reports (e.g. Kunreuther and Fiore (1966), Alexander (1981), Okuyama (2003)) do not tell the story of how different industry sectors and organisations are affected differently by a disaster event. The task is made even more formidable because of the deficiency of relevant information, data and methods in the disaster literature for evaluating recovery after disaster. The development of a framework for system influences on recovery will be one contribution of this thesis. Additionally, the effects of disaster are usually reported in terms of physical damage to the built environment, injury or loss of life. However, there are additional social and economic consequences that extend temporally and spatially. For example, physical damage to buildings and infrastructure can lead to disruption of operations and routines in organisations and communities. This disruption, often intangible or indirect, is frequently difficult to measure and can have regional, national and international repercussions.

Influences on organisational recovery

From the available literature, there are numerous determinants put forward as having an influence on organisational recovery after a hazard event turns into a disaster. These include the level of physical damage, damage to the organisation's non-structural elements such as machinery (Godschalk, 2003; Webb, Tierney, & Dahlhamer, 2002) and also the location of the organisation's premises (Alesch, Holly, Mittler, & Nagy, 2001). Runyan (2006) further illustrates the role that an organisation's physical location plays in determining the types and magnitude of effects experienced by the organisation. The location of the organisation, e.g. in a central

business district or a rural area, as well as the pre-disaster trends and plans that have shaped the area's development are all part of this physical context. For example, Chang and Nojima (2001) showed that urban areas that experienced decentralisation before a disaster often see an acceleration of this trend in the recovery period. Decentralisation can lead to organisations having local customers. Organisations that have a local custom, especially those in retail that rely on foot-traffic, tend to recover more slowly (Alesch & Holly, 1998; Chang & Falit-Baiamonte, 2002; Kroll, Landis, Shen, & Stryker, 1991). Alesch and Holly (1996) in their study of businesses disrupted by the 1994 Northridge earthquake, found that businesses located in highly damaged areas, especially if they depended heavily on a local customer-base, suffered proportionately more than others.

Alesch and Holly (1998), Kroll et al (Kroll, 1991), as well as Tierney and Dahlhamer (1997) have all noted that the size of the business or its financial state before a disaster can act to influence its recovery. Other reasons that could contribute to the recovery of organisations after disaster include the need for the organisation's goods and services after a disaster event, the access to needed resources as well as the leadership style in the organisation (Alesch et al., 2009). Furthermore, organisations affected by disaster face disruptions that flow on to the community and other organisations that depend on them (Tierney & Nigg, 1995; Webb et al., 2002).

The literature also contains accounts of recovery based on empirical observation of community attempts at recovery after disaster, for example Alesch et al., (2009), Webb at al., (2002) as well as Galbraith and Stiles (2006). Other authors have looked at recovery from the perspective of the need for adequate shelter and how this affects recovery (Bolin & Stanford, 1991; Comerio, 1997; Quarantelli, 1982a; Wu & Lindell, 2004). Some studies have specifically focused on the mitigation of critical infrastructure loss or disruption as a way of mitigating the wider effects of disaster (Chang, Svekla, & Shinozuka, 2002; Gordon, Richardson, & Davis, 1998; Rose, Benavides, Chang, Szczesniak, & Lim, 1997).

However, there are not many studies in the organisational recovery literature that have been intentionally conducted to investigate how industry sectors recover from disaster. Some exceptions are Ritchie (2003) and Shrivastava (1988): Ritchie focused on the tourism industry while Shrivastava investigated the accident at Bhopal. Other authors such as Anderson (1969)

and Tierney (1993a, 1997) have also touched on facets of sectoral recovery. In an 18 month long study of 23 organisations involved in the emergency community response after the 1964 earthquake in Anchorage, Alaska, Anderson (1969) reports that 73% of the organisations studied changed structurally and/or functionally because of the earthquake. For some of the organisations in Anderson's study, the disaster led to the emergence of new patterns of change while in other organisations it hastened pre-existing trends. Anderson further found that organisations experienced this change when the earthquake significantly altered their environments, for example, by creating new demands, and when it brought about or intensified already present internal problems such as organisational tensions. In later work, Tierney (1993a, 1997) conducted studies of organisational recovery after the 1993 Midwest floods and 1994 earthquake at Northridge by sampling organisations using business type and business size. For the organisations affected by the floods, results show that a disruption to critical infrastructure services affected the organisations more than the actual flooding. Businesses affected by the Northridge earthquake showed that some of the losses suffered by businesses were caused by disruption to the businesses and were not just from physical damage.

From other analyses of disaster recovery in general, there have been indications that organisation type or industry sector do have a bearing on post-disaster effects on organisations. For example, in examining the effects in the aftermath of the 1989 Loma Prieta earthquake in the San Francisco Bay Area of California, Kroll et al. (1991) found that single location retail and service organisations in the cities of Santa Cruz and Oakland, experienced greater losses and had more difficulty recovering when compared to other types of organisations. Despite these findings, Dahlhamer and Tierney (1998) found that industry sector was not a statistically significant predictor of short-term business recovery in Santa Cruz after the Loma Prieta earthquake or in South Dade after Hurricane Andrew. In a follow-up study with the same businesses conducted by Webb et al. (2002), economic sector was found to be a strong predictor of long-term recovery in South Dade but not in Santa Cruz.

Some of the theories outlined above, on the determinants of recovery, will be tested in chapter 7 of this thesis. Additionally, results from various studies serve to show that there are several factors that interact to influence the recovery of organisations and industry sectors after disaster. Recovery for an organisation begins before the disaster manifests by the existence of organisational planning and environmental conditions for the prevention and detection of

potential disaster. Crises will happen and even the best laid plans will eventually be put to the test. Turner (1976), Smith and Sipika (1993) and others demonstrate how crisis planning alone is insufficient, organisations should also plan how to respond to and manage crises as well as the aftermath. This is in part because the impacts of the disaster are influenced by some of the decisions that are arrived at and actions taken before and after disaster. For example, an organisation with no disaster insurance might have to dip into its much needed own cash reserves to finance recovery, while the loss of a key customer or supplier because of crisis can also affect organisational recovery. This goes back to the system and its environment influencing each other. It should be kept in mind that systems thinking is an aid in analysis of the many interacting components involved in organisational and sectoral recovery.

Supply Web[9] aspects of disaster recovery

Organisations work with and rely on each other to exchange inputs (e.g. raw materials, information) that are then transformed into goods and services for commerce (Lambert & Cooper, 2000). For the provision of goods and services, organisations require input material sourced from various suppliers who together form a supply chain (Lambert & Cooper, 2000), or web. In essence, and taking the systems perspective, all the structures and processes that are used by an organisation[10] to deliver goods and services to its customers are part of its supply web. Harland (1996) states the same. Figure 2-4 illustrates the primary elements in an organisation's supply web and shows the flow of material from suppliers to end customers through processes of conversion and distribution. Of importance in Figure 2-4 is the information that flows in the supply web. The flows in the web are governed by the organisation's control systems and processes and corporate culture.

[9] A supply chain implies a linear relationship between a focal organisation, suppliers, customers and infrastructure used to manufacture/produce and deliver goods and services. From a system dynamics point of view, the interactions between these system actors is non-linear, hence the idea of the *supply web*

[10] The organisation at the centre of a supply web will herein be referred to as the *focal organisation*

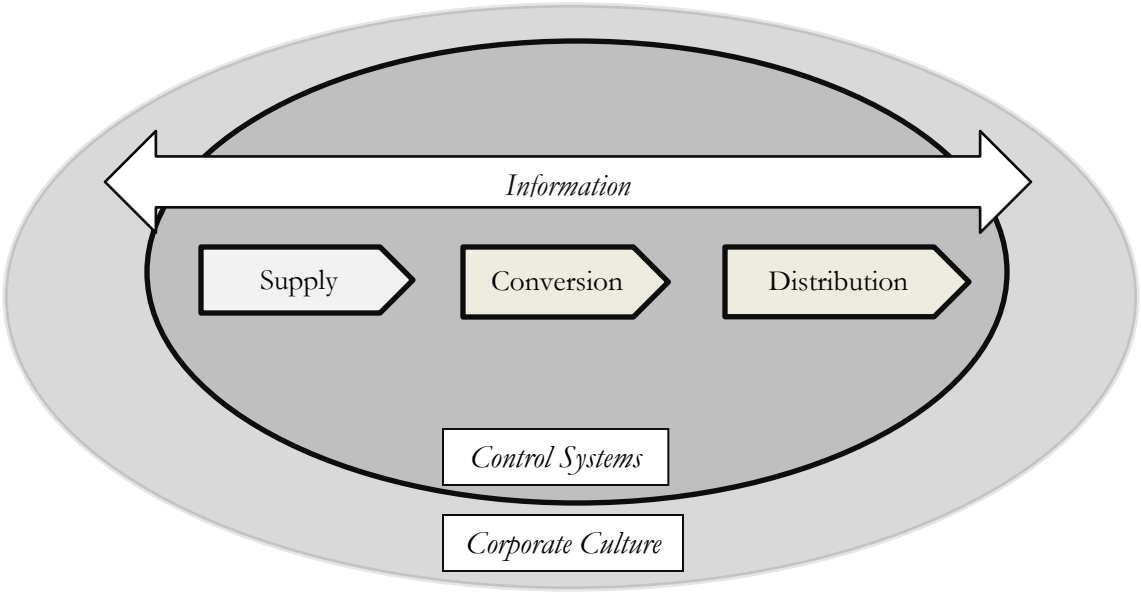


Figure 2-4 - Elements of a supply web (adapted from (Sheffi & Rice, 2005))

Supply Chain Management (SCM) is important as it deals with operations management, materials and production which may be affected by disaster. As one way of increasing and maintaining the competitive advantage of the organisation, the management of its supply web is now seen as vital. Porter (1998) reiterates this when he shows the significance and benefits of utilising an organisation's internal and external connections. From a systems perspective, a supply web has essential parts that include but are not limited to suppliers, production facilities, distribution services as well as customers, all connected by way of the *forward flow of materials and the feedback flow of information* (Stevens, 1989). Such crucial links have a bearing on the recovery of an organisation post-disaster.

Over time, many organisations have spent vast amounts of resources in trying to predict and control their supply web (Choi, Dooley, & Rungtusanatham, 2001). In addition, supply web managers now need to harmonise the need for organisational demands such as low-cost and efficiency with the knowledge that the supply web might fail (Christopher & Peck, 2004; Kleindorfer & Saad, 2005). For instance, in the 1950s, Taiichi Ohno of Toyota developed what came to be known as lean manufacturing (LM) (Sato & Hoshino, 1984) based on increasing efficiency and decreasing waste as a way of managing the supply web. LM is driven by forecast rather than demand which leads to tight coupling between supply and demand and which makes the organisation vulnerable to supply web disruptions (Christopher, 2000; Christopher &

Rutherford, 2004). This means that organisations have to find the balance between an efficient supply web and a resilient supply web.

Several authors (Asbjornslett, 1999; Bak et al., 1988; Pathak, Day, Nair, Sawaya, & Kristal, 2007) are of the view that organisations should understand not only how a disaster event might affect their assets; they also need to prepare and plan for what effects this might have on their supply web and other organisational structures and processes. As supply webs are made up of organisations from various industries, it can be argued that they should be treated as complex adaptive systems that are tightly-coupled. From the systems point of view, the failure of one organisation might lead to adverse consequences to its supply web as the system is interdependent (Christopher & Peck, 2004). For example, a deviation from the usual consumption, as is possible after disaster, can lead to changes in supply starting at one node which could then be amplified along the supply web. This is systemic non-linear feedback. In the beer game[11] designed by Jay Forrester (Sterman, 1989) it was illustrated that this is partly the effect of the individual reactions to the change of information as it travelled along the supply web and the inability of the members of the chain to recognise that the different parts of the supply chain are interconnected. This further shows that the reduction of a whole to its component parts presents a distorted picture of how the individual parts work together.

There has been recognition that the recovery of organisations after disaster can be affected by and is closely linked to upstream and downstream supply web partners (Christopher & Peck, 2004; Finch, 2004). For instance, an organisation's inability to meet a critical customer's supply needs for an extended period might compel the customer to turn to other suppliers for the foreseeable future which would affect the recovery of an organisation at the time when it is crucial for them to be trading. This was seen after the 2011 Japanese earthquake; one of the indirect effects was the disruption to the global motor vehicle supply web. This was due to the inability of organisations in the disaster affected area to supply parts or to assemble motor vehicles (Canis, 2011). This is related to points made in chapter 2.2.2 on the time horizon in a system being important and on system hierarchy and self-organisation. The different but

[11] The beer game was invented by Jay Forrester and is a role-play supply chain simulation that lets students experience typical supply chain problems. It can be played at http://www.beergame.org/the-game, accessed 19 July 2012.

interlinked (sub)-parts of the system have differing timescales. On the one hand customers need goods and services in a certain timeframe which does not match the post-disaster delivery times of affected organisations. However, customers can organise themselves by turning to other suppliers for goods and services.

In today's exceedingly interconnected world, organisations are even more vulnerable to disruptions of the supply web. Organisations now need to learn how to prevent or mitigate this particular kind of risk. Starr et al (2003) advocate this when they state that organisations now face a more complex interdependent type of risk. Notwithstanding any measures an organisation may take, just as with any other type of risk, it is all but impossible to eliminate all risk from the supply web. The supply web is part of the organisation's environment enabling the delivery of goods and services and may be affected in a regional disaster. Therefore, it is vital that supply web aspects be considered in looking at organisational or sectoral recovery.

2.6 Framework for recovery after disaster

The path recovery takes can be long and there are different influences on this as one moves away from the initial point of the disaster event. It is these influences on recovery that are of great import to organisations as well as policy- and decision-makers. This temporal trajectory of recovery can be used to understand that what happens many months after disaster in the main recovery phase is as important as what took place in the response and early recovery phase.

One of the most well-known models for recovery, based on practical experience, is the cyclical process of recovery after [natural] disaster proposed by Haas, Kates and Bowden (1977) and shown in Figure 2-5. The process involves four separate stages: the emergency phase, the restoration phase, the replacement reconstruction phase and the developmental reconstruction phase. The emergency phase begins immediately after the disaster event and can last for several weeks or months depending on the severity of the damage caused by the disaster event. It involves search and rescue operations, debris clearing, and basic utility and infrastructure restoration. The restoration of utilities can include temporary bridges, temporary water and sewage lines, and generator power to critical facilities and systems. The restoration phase includes all permanent repairs to facilities and infrastructure. The replacement construction phase is described as where construction of housing and workplaces takes place while the development reconstruction phase involves putting up correspondent infrastructure such as

churches. Kates and Pijawka (1977) determined that each successive stage takes 10 times as long as the preceding one.

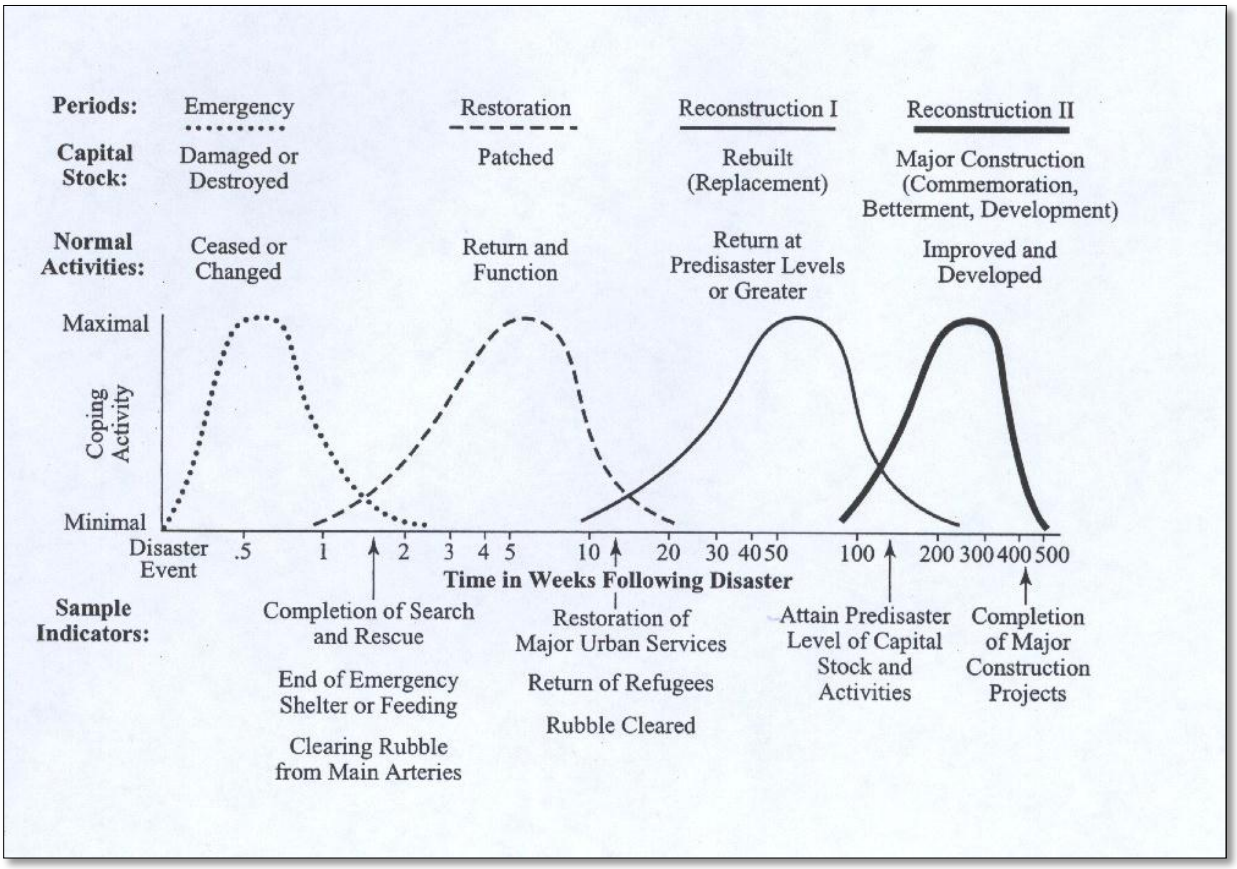


Figure 2-5 - Four phases of recovery (adapted from (Haas et al., 1977))

Kates and Pijawka's model, implies linearity in recovery, which is not the case as different activities may occur at the same time for instance. Additionally, the model by Haas et al. was a good starting point, nevertheless, other successive analyses such as those by Berke et al., (1993) and Bolin (1994) as well as observation of activities after the earthquakes in Canterbury point to recovery not being as orderly or even as certain as Haas et al wrote. The stages are not as clearly defined and often overlap. Additionally, others have tried to add to this generalised framework with narratives of the process of recovery after specific disasters such as earthquakes, floods and Hurricanes (Chang & Miles, 2004; Hummel, Ahlers, Science, & Affairs, 2007; Olshansky et al., 2006; Ota, Maki, & Hayashi, 2009). In the latter literature after the Haas et al. model, there has been a shift in focus to highlight that disaster does not affect different sectors of society the

same: there are variations in the rates and paths of recovery including for industry sectors and individual organisations. This has made more prominent some of the factors that have been reported in the literature as affecting the recovery of different organisations.

In the Canterbury context, apart from recovery not being a linear process, the time horizons in the model by Haas et al do not fit. To start, Canterbury experienced multiple large aftershocks at different times from the initial earthquake on 4 September 2010 event. Another difference that is not accounted for in the Canterbury sequence of earthquakes is that different parts of the greater Christchurch area were affected to varying degrees. Haas et al do not detail what recovery looks like for such a scenario. In general, it would appear that the Haas et al model focuses on the built environment. However, the social, economic, political and other aspects of disaster need to be included also. Some of these aspects are covered in Pugsley's (1973) model on the proneness of structures to failure.

As yet, there has not been a comprehensive account of recovery after disaster from the perspective of the organisation or industry sector and the systemic interdependencies that affect this recovery. Hence the need for a more consolidated and integrated approach to the subject of disaster recovery for organisations. One of the aims of this thesis, and using the system dynamics approach, is to advance the knowledge of the elements that influence the recovery of organisations and sectors.

2.7 Organisational resilience

In 2005, at the United Nations World Conference on Disaster Reduction, the concept of resilience was adopted via the Hyogo Framework for Action 2005-2015. This relates to and calls for the focal points to be on the prioritisation of risk identification and reduction; the enhancement of early warning systems; the building of a culture of safety and resilience, and the strengthening of disaster preparedness and response capabilities (UNISDR, 2005).

In order to avoid repeated crises or disasters that leave organisations unable to cope, the idea of organisational resilience has been put forward as a means for organisations to maintain their ability in the face of crisis (Hamel & Välikangas, 2003; Seville et al., 2008; Tierney, 2003). One argument in this thesis is that this general concept of organisational resilience should be extended into that of organisational *disaster* resilience. Several authors (Brewer, Weinstein, Cuite,

& Herrington, 2004; Carpenter, Walker, Anderies, & Abel, 2001; Couto, 1989; Tierney, 2008) have, in recent, years written on organisational disaster resilience. It has been proposed as an attribute essential for organisations in disaster and variously encompasses crisis prevention, crisis or emergency management, organisational learning, leadership and strategy among others. For this thesis, the definition of resilience by Seville et al., (2008, p. 18) will be used:

> *the ability to survive crisis and thrive in a world of uncertainty.*

Figure 2-6 illustrates that organisational disaster resilience is not separate from the resilience of other actors such as the individual, the family and the community (see section 6.6 for more detail). Additionally, depending on the scale of a crisis or disaster (see Quarantelli (2006) and McManus (2008)). McManus (2008) further describes the types of crisis as:

- → distal - affecting the organisation through its supply web);
- → localised - organisation specific incidents that cause disruption;
- → societal – nationwide but where the organisation's physical infrastructure is undamaged but staff are unable to work; and
- → regional – significant physical damage and disruption of lifelines in a large area.

From these descriptions of crisis types, this thesis puts forward that there are also two, interrelated, levels of organisational resilience dependent on the scale of a crisis. The two interrelated levels of organisational resilience: business-as-usual (BAU) organisational resilience and organisational disaster resilience. Figure 2-6 shows that BAU organisational resilience is associated with crises or disasters of a distal nature to the organisation, while organisational disaster resilience is associated with crises on a regional scale. For organisational disaster resilience, the affected organisation may be affected to a greater extent as a result of the region they are in being affected. This means that not only are the organisation's assets affected but also those of their staff, the community the organisation exists in as well as other organisations in the region. As a result of the scale of a regional crisis or disaster and the number of people or organisations affected, an organisation may find itself in need of resources it may not usually need, e.g. earthmoving equipment after an earthquake. Additionally, an organisation may be competing for these scarce and much needed resources with other affected organisations or

communities in the region as they all try to recover. In chapter 10, the dissimilarities between BAU organisational resilience and organisational disaster resilience are expanded on and it is shown how business-as-usual resilience can be used as a foundation to advance organisational disaster resilience.

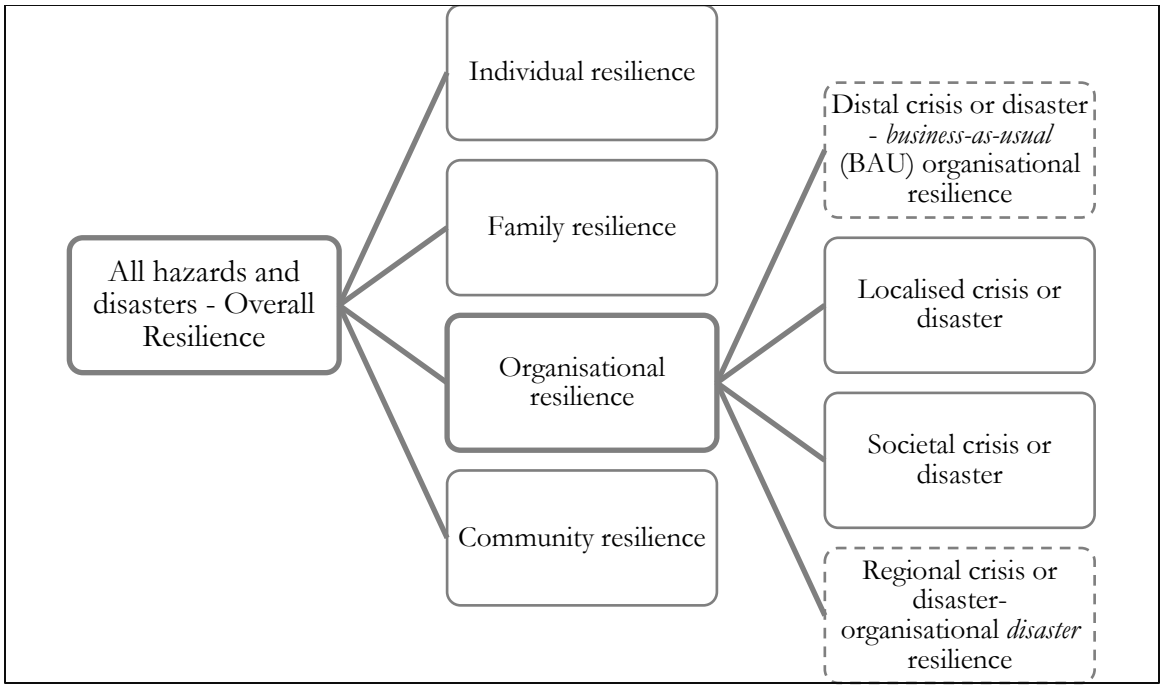


Figure 2-6: The different interconnected facets of resilience as used in this thesis

While the origin of resilience as a concept is still being debated, it can be said that the idea of resilience was widely disseminated from the field of ecology via *Resilience and Stability of Ecosystems* (Holling, 1973). The origin of the word resilience is Latin. From the *Oxford English Dictionary*:

> Latin origins < L resili (ēns), prp. of resilīre: *the power or ability to return to the original form, position, etc., after being bent, compressed, or stretched* (OED, 2010).

It appears that the OED definition assumes that a system will always bounce back. This is not the case as all systems have a breaking point, resilience is finite. From the academic perspective, resilience has been given many different meanings depending on the researcher or the area of research. Table 2-3 shows some of the definitions of resilience from the different disciplines.

Table 2-3: Definitions of resilience from different disciplines and research areas

Definitions of resilience from different disciplines and research areas		
Author(s)	**Academic/research discipline**	**Definition**
Holling	Ecology	a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables (Holling, 1973)
Horne & Orr	Organisational and human resource development	resilience is a fundamental quality of individuals, groups and organisations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behaviour (Horne & Orr, 1998)
Perrings	Environmental and resource economics	resilience is a measure of the ability of a system to withstand stresses and shocks – its ability to persist in an uncertain world (Perrings, 1998)
Comfort	Public and international affairs (public policy analysis)	the capacity to adapt existing resources and skills to new systems and operating conditions (Comfort et al., 1999a)
Petak	Public administration	the system's ability to make a smooth transition to a new stable state in response to the disturbance (Petak, 2002)
Bruneau et al	Earthquake engineering (community disaster resilience)	the ability of social units (e.g., organizations, communities) to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes (Bruneau et al., 2003)
Tierney	Sociology	a property of physical and social systems that enables them to reduce the probability of disaster-induced loss of functionality, respond appropriately when damage and disruption occur, and recover in a timely manner (Tierney, 2003)
Christopher and Peck	Logistics	the ability of a system to return to its original state or move to a new more desirable state after being disturbed (Christopher & Peck, 2004)
Rose	Economics	the ability or capacity of a system to absorb or cushion against damage or loss…(more general definition) that incorporates dynamic considerations, including stability, is the ability of a system to recover from a severe shock (Rose, 2004)
Walker et al	Ecology	the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker, Holling, Carpenter, & Kinzig, 2004)
Hollnagel et al	Engineering	the ability of systems to anticipate and adapt to the potential for surprise and failure (Hollnagel, Woods, & Leveson, 2006)
Seville et al	Business and engineering	an organisation's ability to survive, and potentially even thrive, in times of crisis (Seville et al., 2008)
UNISDR	Disaster reduction	the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNISDR, 2009a)

From the numerous definitions listed in Table 2-3, a central theme emerges. The various disciplines use the terms *resist*, *absorb* and *anticipate*; thereby emphasising a pro-active as opposed

to re-active stance in terms of resilience. These definitions also indicate that most disciplines regard resilience as an end result of other contributing factors rather than as a process. At the same time, the major line of thinking in terms of resilience is the concept of bouncing back (Paton, 2007). However, it can be said that resilience especially after disaster is about more than just bouncing back, it also requires adaptability and transformability as the post-disaster context is markedly changed. As stated earlier, the definition of organisational resilience used in this thesis is that of Seville et al (2008, p. 18): *the ability to survive crisis and thrive in a world of uncertainty*. The reason for using this definition of organisational resilience is because it is not restricted to one type of crisis, instead it is all encompassing. As well, it talks of the uncertainty of an organisation's environment and the organisation's possibility to thrive, i.e., to adapt post-disaster.

2.8 Organisational disaster resilience

In this thesis, the perspective on organisational resilience is that of *organisational disaster resilience*. This is a focus on how organisations can become less vulnerable and make themselves more resilient to disaster. Extreme events can cause damage to physical infrastructure, cause disruptions to organisation and impinge on people's livelihoods. Disruptions can adversely affect the operations of organisations and investments in resilience can give a business a competitive advantage over organisations not as well prepared for dynamic circumstances.

A search in the disaster literature for organisational disaster resilience shows that this is a relatively young but growing field. In the disaster scholarship, there exists work on the disaster resilience of communities by Chang and Shinozuka (2004), Paton (2007) and Mayunga (2007). In addition to this view, there is an emerging, but limited, body of literature that links an organisation's level of resilience to its recovery post-disaster (Bruneau et al., 2003; Chang, Rose, Shinozuka, Svekla, & Tierney, 2000). It appears that this growing focus on organisational disaster resilience stems from the awareness that some organisations adapt better than others during times of crisis and turbulence. There is recognition that resilience is a fundamental organisational attribute that facilitates adaptation, transformability, learning and functional stability post-disaster. Tierney and Bruneau (2003, p. 14) say of disaster resilience that it

> *reflects a concern for improving the capacity of physical and human systems to respond to and recover from extreme events.*

From the Resilience Alliance (2012), resilience as pertaining to socio-ecological systems (of which organisations are a part) has three defining aspects:

- → the amount of change the system can undergo and still retain the same controls on function and structure;
- → the degree to which the system is capable of self- organisation (recovery); and
- → the ability to build and increase the capacity for learning and adaptation.

For this thesis, the Resilience Alliance make an important point that a lot of the work reviewed for this thesis does not: the amount of change the system can undergo. This means that resilience is not infinite and every system can break depending on the conditions. Additionally, the adaptive capacity referred to is taken to be the ability of the actors in a system to influence or direct their resilience. This is a trait of systems that learn and store knowledge. Walker and Meyers (2004) write that the capacity for forward planning demonstrates the difference between resilience in ecosystems and social systems.

2.8.1 **The need for organisations to be disaster resilient**

For some organisations struggling to recover after disaster, the destruction and the task before them can seem insurmountable. Government departments, critical infrastructure providers, local authorities, emergency services, businesses, civil society and other community organisations can all be affected by disaster and should therefore all strive to be disaster resilient. In addition, when an organisation can demonstrate that it is disaster resilient, this leads to an elevated level of trust in the organisation from other organisations or people that work with it. For example, in the case of critical infrastructure providers, the Australian Resilience Expert Advisory Group (2011) write that a benefit of this is the possibility for less regulation from the government for organisations seen as resilient.

While organisations that are owned or run by the government may be under mandate not to fail, the same cannot be said of private enterprise. However, these organisations, part of larger systems, also carry responsibilities that mean that they should be able to continue to some extent, in a disaster situation (A. B. Carroll, 1991; Lindgreen & Swaen, 2010). These responsibilities extend to the organisation's employees (and by extension the communities these

employees belong to), customers, supply chain partners and shareholders. Were an organisation to close or to take a long time recovering after disaster, this would have an effect on the livelihoods and operations of many who depend on it.

To extend this further, organisations are also a part of the social and economic fabric of the regions they contribute to and could affect a whole region's social and economic wellbeing if they failed. For example, organisations whose goods and services are necessary for a region's economic growth and by extension its recovery (Popp, 2006). In addition, organisations also contribute to the community and the region by way of the rates and taxes they pay. Prolonged disruption or closure of business may put a financial strain on the local or national government which in turn could have a bearing on development plans (Chang, 1983). Other organisations that need to be disaster resilient are those that are part of civil society [12]. Aldrich (2008) examined the role of civil society in recovery after the Kobe earthquake in Japan and concluded that the quick recovery of some parts of the area was because of the work carried out by civil society.

2.8.2 **Organisational resilience – from theory to application**

For most organisations, the overall concept of resilience, its characteristics and how to measure them remain intangible. Sutcliffe and Vogus (2003) report that there is increased resilience when emphasis is placed on the positive attributes of individuals and the organisation. According to Bruneau et al (2003), it is possible to quantify the effects of resilience beforehand by calculating the losses incurred as a result of resilient actions not carried out before a crisis. This quantification would be the next step in the previously discussed qualitative indicators proposed by Heinrich and Pugsley (see section 2.3.2).

Other actions, or metrics, leading to resilience include how long it takes to resolve a crisis should it occur (Rose, 2004). Resilience can also be measured as savings made by actions such as sustainable production methods (Fiksel, 2006). Being able to measure resilience in such tangible ways would help to make resilience a point of discussion in organisational boardrooms as it can be shown how resilient actions can add to the bottom line. From the system dynamics perspective, measures of resilience could be how far from a pre-disaster state the system deviates

[12] The Oxford English Dictionary (OED) defines civil society as 'that aspect of society concerned with and operating for the collective good, independent of state control or commercial influence'. Accessed on 19 July 2012 from www.oed.com

or the time taken for the system to return to a pre-disaster state or better, for example revenue earnings for organisations. This makes use of the system characteristic of negative feedback which is goal seeking. There is more discussion in chapters 7 and 10 on revenue and time as measures of disaster resilience.

In some cases, organisations fail to realise that environmental changes outside the organisation, such as those brought on by disaster, necessitate changing the goal(s) of the organisation (Evan & Black, 1967; D. Kelly & Amburgey, 1991). Other actions of resilient organisations include redefining the organisation's goals and aligning these goals with the organisation's operations (Rummler & Brache, 1990). The equivalent of this process in systems terms is systems re-optimisation[13].

Additionally, dealing with a crisis effectively is part of being resilient. Knight and Pretty (1996) showed that organisations that did not deal with crises effectively or adequately suffered a 10% decrease in the price of their stock after the first week of the crisis and a 15% decrease below pre-crisis prices in the first year following the crisis. Alternatively, organisations that effectively managed a crisis had just a 5% stock price dip in the wake of the crisis and the stock price recovered quickly in the year after the crisis (Knight & Pretty, 1996). For a resilient organisation, the emphasis should not be on *disaster* preparedness but on *general* preparedness for all hazards and for day-today activities (Reason, 1998).

Lastly, apart from being able to determine the organisation's level of resilience, organisations are also concerned with knowing when they should evolve from a certain level of resilience to another, for instance after disaster when there are many changes and uncertainties. The primary question is: should organisations strive to get back to the level of disaster resilience they had prior to the disaster event? On the contrary, a resilient system need not be stable in the traditional sense. Lebel et al (2006) posit that a resilient system should be stable in being able to withstand turbulent conditions and still survive, adapting and changing if necessary.

[13] To optimise the system and redefine the goal, principles from systems engineering can be used (for more on this, see Laplante (2007), Sommerville (2000) and Bhamadipiti (2010)).

2.8.3 **Measuring organisational resilience**

Sutcliffe and Vogus (2003) make the link between organisational resilience and positive performance at the individual and organisational levels. They also argue that resilience should be viewed as always being developed, as an ability that develops over time from continually managing risks. From a systems viewpoint, it can be concluded that resilience is relative, is an emergent property of the system and changes depending on specific circumstances, i.e. resilience displayed in one situation may not be sustained over time or transposed to other circumstances. It is implied in this developmental perspective that resilience depends on the presence of inherent or dormant resources that can be activated and put together using various permutations as the situation warrants. For example, Maguire and Hagan (2007) posit that the development of emergency plans must use some of the inherent existing organisational social resilience as part of their foundation.

Before disaster strikes, the resilience of an organisation can be strengthened. However, as has been shown, the idea of resilience is broad and multifaceted. A cardinal point is how to recognise and determine the level of resilience for an organisation. Therefore it is helpful to break it down into components that are understandable, easily usable, can be measured, are of relevance and explain the overall concept. Some work has been undertaken in this area. McManus (2008) and Stephenson (2010), starting with an appraisal of the wider organisational literature and using case studies, surveys and focus groups, went on to identify 13 organisational characteristics that together form the umbrella concept of organisational resilience. These 13 indicators of organisational resilience can be used by organisations to appraise their overall level of resilience and based on the score for each indicator can also be used for identification of any possible areas of improvement. These indicators of organisational resilience are sometimes referred to as the attributes or components of organisational resilience.

The Benchmark Resilience Tool (BRT-53) (Resilient Organisations, 2010b) is a multiple indicator measure of resilience. Quantification of indicators of resilience allows for the measure of differentiation of resilience at different points in time. For recovery after disaster, it is as yet unclear which, if any, of these indicators of organisational resilience has a more substantive effect. In chapter 10, it will be shown how the BRT-53 can be enhanced for organisational disaster resilience.

The 13 indicators of organisational resilience

As a result of the work of McManus (2008) who investigated the resilience of New Zealand organisations, three pillars of resilience were identified, along with the possibility to derive what was called the *Relative Overall Resilience* or ROR of an organisation. The indicators are shown in Table 2-4. Each of McManus' three pillars of resilience comprises five indicators of resilience aim to capture the different aspects of this complex idea.

As discussed in previous paragraphs, resilience is subjective and contextual. McManus' indicators of organisational resilience assume a one-size-fits-all model for organisations, and do not consider that there may be different aspects of resilience required for organisations in different circumstances. For instance, an organisation's level of resilience pre-disaster is likely not the same post-disaster. In a system, there are different feedback loops dominant at different times and contributing to its resilience. For instance, Pugsley (1991), in writing on how to predict proneness to failure included in his indicators environmental aspects such as finance and politics which are not explicitly shown in McManus' model. Additionally, McManus' indicators are also qualitative only. This is good start to measuring organisational resilience. For organisations, the addition of a quantitative aspect to McManus' model is beneficial. This is because a purely qualitative measure would make it difficult for them to know what their level of resilience was or how much effort was needed to improve it.

Table 2-4 - Pillars and indicators of organisational resilience

Pillars and indicators of organisational resilience						
Pillars of resilience	**Situational awareness**		**Management of keystone vulnerability**		**Adaptive capacity**	
Indicators of Resilience	*SA1*	Roles and responsibilities	*KV1*	Planning strategies	*AC1*	Silo mentality
	SA2	Understanding of hazards and consequences	*KV2*	Participation in exercises	*AC2*	Communications and relationships
	SA3	Connectivity awareness	*KV3*	Capability and capacity of internal resources	*AC3*	Strategic vision and outcome expectancy
	SA4	Insurance awareness	*KV4*	Capability and capacity of external resources	*AC4*	Information and knowledge
	SA5	Recovery priorities	*KV5*	Organisational connectivity	*AC5*	Leadership, management and governance structures

Adapted from Organisational Resilience in New Zealand (McManus, 2008)

The later work of Stephenson (2010), based on that of McManus (2008) and carried out with organisations based in Auckland, led to the benchmarking of organisational resilience with the aim of giving organisations a standard for resilience that they could use as a comparison. From the Auckland study, based on statistical analysis, Stephenson also developed a restructured, revised and more refined model of organisational resilience that had 13 indicators of resilience illustrated in Table 2-5.

Table 2-5: Newer model of organisational resilience

Organisational resilience factors and indicators contained in newer model	
Adaptive Capacity	**Planning**
Minimisation of silo mentality	Planning strategies
Capability and capacity of internal resources	Participation in exercises
Staff engagement and involvement	Proactive posture
Information and knowledge	Capability and capacity of external resources
Leadership, management and governance structures	Recovery priorities
Innovation and creativity	
Devolved and responsive decision making	
Internal and external situation monitoring and reporting	

(Stephenson, 2010, p. 176)

The advantage of Stephenson's model is that it is quantitative. However, this latest model by Stephenson (2010) also assumes that the indicators would work for organisations of different types. As organisations are different and have different entities they interact with, this may not be the case. For instance, minimisation of silo mentality or leadership, management and governance structures may not be applicable to an organisation with no departmental barriers or with different leadership structures. As an example, Handler and Kram (2004) concluded that leadership and governance are not the same in family businesses as in other organisations.

Stephenson included traditional financial measures (cash flow, return on investment-(ROI) and profits) used to measure a firm's excellence or viability. This is useful for organisations as these are measures already in use or are easy for the organisation to understand. However, as was also noted by Chakravarthy (1986), these conventional measures, such as ROI and profits, have the limitation that they are usually taken in isolation, and while important, show an organisation's history but not the direction in which it might go. Graham (2001) calls these lagging, or past, indicators which should be used in conjunction with leading (or future) indicators such as how

aware employees are of services to be offered in future, as well as the potential value of these services (monetary or otherwise) to the organisation (see chapter 10 of this thesis). Examining the nature and type of a firm's decisions and shifts, via its strategy for example, could be used as an alternative measure (Evan, 1978). As well, intangibles like team spirit should not be devalued when measuring an organisation's performance as these also give an indication of the state of health of an organisation (Senge, 2006). Stephenson's (2010) work asks about staff satisfaction at a broad organisational level. In addition to overall staff satisfaction questions, the organisation could ask for specific reasons for the level(s) of satisfaction of their staff. In short, measures that are relevant to the organisation and the context should be used.

Stephenson's model of organisational resilience provides organisations with metrics for measuring organisational resilience. Organisations can use changes in these metrics to monitor changes in organisational resilience over time. Stephenson's model would benefit from having different versions to suit different organisations and different industry sectors as well as questions specifically to do with disaster resilience. One of the aims of this thesis is to highlight how Stephenson's model could be advanced, especially for organisational disaster resilience. This is discussed in detail in chapter 10.

Lastly, Stephenson's quantitative model leads to an overall organisational resilience figure. The overall organisational resilience score is useful as a general marker for the organisation's change in resilience. However, organisations concentrating on only this aggregated measure of resilience may find that it does not aid in making improvements to specific aspects of their resilience. Additionally, both McManus and Stephenson talk of the resilience of the organisation. However, organisations are part of larger systems. Therefore, both the resilience of the organisation and the resilience of the system it is a part of need to be measured. This can be defined dependent on the purpose or goal of the system.

Other indicators of organisational resilience in the literature

There are other occurrences of organisational resilience in the literature and they have all been used in the context of organisations overcoming turbulent environments. As with the definitions of resilience, the indicators or attributes of organisational resilience are also assigned different labels by different researchers. However, the descriptions have a similar theme.

Lengnick-Hall and Beck (2005) characterise organisational resilience as having three components: cognitive, behavioural and contextual. Meanwhile, Walker et al (2004) write that factors important to the future direction of an organisation are resilience, adaptability and transformability. Resilience is further broken down into four parts, latitude, resistance, precariousness, and panarchy. Adaptability is defined as the capacity of actors in the system to influence resilience whereas transformability is the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable.

Rose (2004) talks of organisations having inherent and adaptive types of resilience. Tierney (2008) writes about the 4-R framework of resilience that also applies to organisations and includes technical, organisation, social and economic aspects. Bell (2002) also cites five pillars of organisational resilience: leadership, culture, people, systems and settings. Horne and Orr (1998) have gone further than most authors and aligned organisational performance to their *seven streams of resilient behaviour*:

- → community;
- → competence;
- → connections;
- → commitment;
- → communication;
- → coordination; and
- → consideration.

These seven streams, if present in organisations, have been identified as actions that contribute to the creation of a resilient organisation. Horne and Orr state that the streams are intertwined. This is in line with the notion of organisations as systems that is used in this thesis. According to Horne and Orr (1998), community is the employees' understanding of the purpose, vision, mission and values in the organisation while competence is the repertoire of skills the employees possess to meet the demands of changing environments. The connections stream deals with the extent of an organisation's social support in periods of crisis, commitment is the ability of all units in the organisation to work together effectively in times of change. Communication focuses on sharing relevant information during these times of change. Coordination is the act of

arranging the entire system in order to have effective results. The last stream, consideration, is about factoring in the human element in the everyday dealings of the organisation.

The measures of organisational resilience from Lengnick-Hall and Beck, Rose, Tierney, Bell and Horne and Orr, while descriptive, do not detail how organisational resilience can be measured so that organisations can use these metrics for improvement. This is especially vital after a disaster.

2.8.4 **The case for investment in organisational disaster resilience**

If any measure of disaster resilience is to be useful to the organisation, it should be invested in prior to any disaster and improved upon as the organisation learns. For instance, Knight and Pretty (1996) and Rose (2004) demonstrate that organisations can minimise disaster losses as a result of engaging in resilient pre-disaster actions. Resilience is necessary because organisations now have to deal with situations where new problems come up and the old methods of analysing problems have themselves become problems (Jacques, 1996). Additionally, organisations now have to compete with *everyone for everything from everywhere* (Sirkin, Hemerling, & Bhattacharya, 2008, p. 6). Being able to adjust to different situations such as those brought on by disaster, being creative and learning are some of the traits and actions of a resilient organisation.

This means organisational disaster resilience is more than just returning to the situation as it was before a disaster. Adapting to suit changing circumstances is another characteristic of a resilient organisation. According to Pascale and Athos (1981), one indication of an organisation that has adapted effectively is that it can partner its strengths and its abilities with the opportunities presented by the environment, and then choose a strategy that aligns with these opportunities. Pascale and Athos' advice, while very true, may not take into account the sustainability of taking up these opportunities if the long-term purpose of the organisation is not considered. Moreover, the ways of doing business grow more intricate and competing financial, social, and political interests increase. Leveson (2002) and Perrow (1986) acknowledge that as a result of such interconnectedness systemic risk cannot be avoided; rather, the innate risks in the way organisations operate should be recognised as much as possible. Furthermore, the system should be made resilient to external and internal factors (Thain & Goldthorpe, 1989) to ensure continued existence. It is tempting to try and design risks out of a system; however, this is close

to impossible and may create more complications as the system might then not be fit for purpose.

Worldwide, in just the last few years, numerous events have had a bearing on organisational recovery and resilience. These include events such as the boxing day Tsunami of 2004 in which many lives were lost and which had a negative impact on the tourism industry of the majority of the countries affected (Birkland, Herabat, Little, & Wallace, 2005; Majumder, 2005). The importance of disaster resilience is so that in times of disaster an organisation has *the ability to accept change gracefully* (H. D. Foster, 1997, p. 6) and without near permanent collapse (Bolin & Stanford, 1998; H. D. Foster, 1997). Therefore, there is a need to investigate what actions can lead to organisational and sectoral disaster resilience.

2.9 The frame of reference for this research

Organisations in New Zealand are exposed to a wide range of hazards, natural and otherwise. While the focus in this thesis is on organisations and sectors, there is recognition that especially in crises that are regional, the recovery of the organisation, the sector, the community and the region are very closely linked. The frames of reference used in this thesis are from the literature on organisations, crisis management and disaster recovery. These are brought together through the use of the grounded theory and system dynamics approaches.

This research therefore addresses the gap in the literature on the recovery of individual organisations as well as industry sectors and also the interlinked nature of organisational recovery after disaster by taking a systems (or holistic) view of disaster recovery. There is also a gap in addressing what aspects are most important in organisations in the response and short-term recovery phases of disaster. Moreover, it has been noted that much of the existing research and documented work on organisational crisis and disaster management has been focused on the internal working of an organisation, not taking the organisation in the context of its environment (Evan, 1965; Senge, 2006). Using the organisational, crisis management and disaster recovery literature points of view, underpinned by systems thinking helps in understanding how organisations belong to the bigger picture that is Canterbury post 2010-2011 earthquakes. Consequently, another component of this thesis will be to start to answer the question of what are some of the determinants of recovery, prosperity or failure of an organisation and sector after a major hazard event.

Furthermore, in the disaster and organisational literature, there is a gap in knowledge of how different industry sectors are affected by disaster as well as how they recover. As industry sectors and the interconnections between them play a crucial role in the economic and social well-being of an area, the way(s) in which they recover from disaster is conspicuous in its absence from the disaster literature. This is even as there has been some research focused on how (mainly) for-profit organisations fared after other disasters similar to the earthquake(s) in Canterbury, New Zealand. Examples include the earthquakes in San Francisco (Webb et al., 2002) and Northridge (Bolin & Stanford, 1998; Tierney, 1997) in the USA as well as Gisborne (F. Powell & Harding, 2009) and the Ruapehu eruptions (Miller, Paton, & Johnston, 1999) both on New Zealand's North Island. However, the damage and effects of these disasters and the subsequent recovery have been scrutinised from a broad local or national level (Alesch et al., 2001) masking how industry sectors were particularly affected and how they fared afterwards. In contrast, it has been documented that small business might have difficulty recovering (Alesch & Holly, 1998; Runyan, 2006) and that certain individual sectors such as construction and manufacturing might experience a boom in the immediate aftermath of an earthquake (Tierney, 1993a; Tierney & Webb, 2001). However Tierney's work does not extend to the development of a recovery framework for organisations and industry sectors and the systemic linkages involved. Adding to this segment of the disaster scholarship will be another contribution of this thesis. From the disaster recovery and organisational bodies of work, some of the other theories that will be tested in this thesis are what determines recovery for organisations and sectors and is it a linear process?

Additionally, in this PhD research, the recovery from, resilience to and short-term impacts of disaster on individual organisations, localities (central business districts) and multiple industry sectors (e.g. hospitality, trucking, retail) will be analysed. Included in the study is the investigation of the transitory effects of disaster on different sectors, for example as a result of increased or decreased demand for goods and services at certain points after the earthquake. In this work, specific attention is also paid to the repercussions of multiple organisations in a supply chain being disrupted by the same event as well as the effects when a critical node in a supply chain is shaken by disaster. Apart from investigating the key elements of recovery for organisations and

industry sectors, another contribution of this work will be through the addition made to the existing literature on organisational disaster resilience.

In light of the above, it is imperative that a new, systemic, way of looking at organisational and sectoral recovery from disaster be taken up by organisations as well as organisational and disaster scholars. Keeping in mind the extent of the Canterbury series of earthquakes and the number of organisations involved, the analysis in this work is that of a regional disaster perspective.

From the previously outlined retrospective on the organisational, crisis management, disaster recovery and systems thinking literature, research aims and questions were developed to aid in achieving the intended contributions of this work.

2.10 Research Aims

The aims of this research are to:

- → *Investigate the major factors involved in the recovery of organisations after a major (regional) hazard event.*
- → *Determine the system dynamics involved in the recovery of organisations and sectors.*
- → *Review the work done by Stephenson and McManus, enhance the Organisational Resilience Measurement Tool and contribute to the overall aims of ResOrgs.*
- → *Explore ways of enhancing the (business) case for resilience.*

2.11 Research Questions

From the aims stated above, the research questions are:

- → *What factors - severity of the effects (direct and indirect) of a major hazard event, or the pre-or post-event performance - have substantial effects on the recovery of organisations and what are the relative magnitudes of these effects?*
- → *What are the system behaviours that contribute to the recovery of an individual organisation, a sector and between sectors?*
- → *Which of the indicators of organisational resilience are prominent in a regional disaster?*
- → *What is the link between resilience and organisational performance?*

2.12 Chapter summary

In this chapter, it has been shown that the literature on different aspects of the recovery process and that on how organisations deal with crises continues to expand. This chapter reviewed the critical points of current knowledge in the literature on organisational crisis management, disaster recovery, disaster resilience and organisations as systems. In the chapter, it was further emphasised that disaster recovery needs to be looked at from the sectoral perspective and within a system dynamics framework. This knowledge is valuable not only for strategy and policy formulation after disaster but also for future decisions for organisations and sectors.

However, there has so far not been a system dynamics model or framework that brings together the complementary disciplines reviewed, to outline the process of recovery for organisations and industry sectors in a disaster environment as well as what that might involve. Specifically a framework that takes into consideration the systemic nature of organisations and industry sectors, to track their recovery from almost immediately after a disaster event to the short-term. A framework that takes into account that recovery from disaster is a long, complex, inter-organisational and systemic affair. In this thesis, the frames of reference utilised are from the existing literature on organisations, crisis management and disaster recovery. Importantly, these will be underpinned by the grounded theory and systems thinking approaches and used to investigate and establish the key elements of recovery for organisations and sectors after the 2010 – 2011 earthquakes in Canterbury. The gaps to be addressed in this thesis include:

- → considering organisations and industry sectors as systems and belonging to larger systems, what are some of the determinants of recovery, prosperity or failure after the 2010-2011 Canterbury series of earthquakes?;
- → what are some of the aspects that are important in organisations in the immediate response and short-term recovery phase of disaster?;
- → what are some of the key characteristics of disaster resilience for organisations and industry sectors as well as the interlinked nature of organisational and sectoral recovery?; and
- → what is contained in a systems dynamics post-disaster recovery framework for organisations and industry sectors?

The next chapter is on the rationale used for the design of the research.

3 Research methods and design

Recovery from any major event is long term and can last anything from 5 years to decades after an event. In the overall recovery process, this research was conducted over the two year period spanning response and short-term recovery. The study was carried out starting from a few weeks after the 4 September, 2010 M_W 7.1 Darfield earthquake and was designed to follow sampled organisations and industry sectors through their recovery process after the 2010 and 2011 series of earthquakes. The aim of the study was to chart the effects and consequences, in the immediate and short-term, of the earthquakes on these selected organisations and industry sectors in Canterbury.

The study utilises a multi-method research strategy which draws on the strengths of different research methods. This way of conducting research is sometimes known as *triangulation* (Denzin, 2009; Robson, 2002). Specifically methodological triangulation, a process of combining quantitative and qualitative approaches, was employed for analysis of surveys, contextual interviews and case studies. The combination of quantitative and qualitative approaches ensures a richer data set as the two methods can be used to collect data that is complementary. This is seen as advantageous for research (Campbell & Fiske, 1998; Jick, 1979). Furthermore, all of the data were analysed from a system dynamics perspective which aids in the analysis of situations with numerous interrelated elements. The system dynamics approach is used because the post-disaster situation being analysed is complex and dynamic and stems from the interaction of physical, social, economic, political and environmental systems. In the case of organisations, their recovery involves all these facets as well as the possibility of an affected organisation having an effect on other organisations it interacts with or vice-versa.

Given the sensitive and emotive nature of this research, measures were taken to ensure that it would be conducted in an ethically sensitive manner. This included seeking and receiving permission from the University of Canterbury Human Ethics Committee (HEC).

3.1 Sample group[14]

The main research site was the earthquake hit Canterbury region on the South Island of New Zealand; with a focus on the greater Christchurch area, Waimakariri district and Selwyn district. The sectors that make up the sample group were selected so as to reflect various elements of the Canterbury economy. For the purposes of this thesis, a group of organisations that operate in the same segment of the economy or share a similar business type are characterised as making up an industry sector. The selection of the sectors was done in collaboration with a research team comprised of organisational, resilience and recovery experts. The experts were consulted for their knowledge of the economies and business landscapes of Christchurch and Canterbury.

The reason for selection at the sector level was to establish the effects of the recovery on a whole sector as well as individual organisations in a sector. Also, to make the research valid and applicable, one of the factors in picking the sample was that some of the organisations should belong to industry and geographic sectors that were an integral part of the economy of Christchurch. Additionally, the sectors selected had interactions with each other. This to better show the effects that sectors can have on each other's recovery. From a system's perspective, the primary aim of this thesis is to investigate the key elements of recovery and resilience for industry sectors. The sectors selected fulfilled this purpose.

Therefore, included in the overall sampling frame were sectors noted in the Canterbury Regional Economic Development Strategy (CREDS) 2005 – 2015 part of whose vision includes making *Canterbury a world leading regional economy founded on innovation, diversity and sustainability* (Canterbury Economic Development Co. Ltd., 2009). Included in CREDS are the agricultural, information and communication technology (ICT), manufacturing and business services sectors; not all of these sectors were selected for the study. After some discussion a shortlist of other possible sectors seen as vital to the recovery of Canterbury after the earthquake was drawn up. This shortlist was further whittled down to the final list of sectors shown in Table 3-1.

[14] A more detailed description of each sample group can be found in chapter 4.

Table 3-1: Final list of industry sectors selected for the study

Final list of industry sectors selected for the study		
Sector or sub-sector	**Details of sector or sub-sector**	**Brief explanation for inclusion in study**
Construction	Building suppliers	involved in the repair, remediation, restoration and reconstruction process of the built environment. Also may possibly experience an increase in demand during the recovery process
Critical Infrastructure (Lifelines)	Engineering and non-engineering	provision of essential services to all other sectors in the study
Fast Moving Consumer Goods (FMCG)	Food producers, supermarkets, dairies, service stations with dairies	vendors of consumables like milk, bread and other perishable goods part of customer non-discretionary spending
Hospitality	Bars, cafés, restaurants	track the discretionary spending habits of the general population and how this affects recovery
Information and Communication Technology (ICT)	Light manufacturing, software and professional service providers	high-growth sector identified as a key component of Canterbury's regional economic plan
Transport	Trucking	part of the logistics chain for all the other industry sectors in the study
Christchurch Central Business District (CBD)	Mixed business types. The Christchurch Central Business District (CBD) is defined as the area bound by the four Avenues: Bealey Avenue, Fitzgerald Avenue, Deans Avenue and Moorehouse Avenue	economic hub of Christchurch, heavily affected by the 22 February 2011 earthquake
Kaiapoi Town Centre	Mixed business types. The Kaiapoi Town Centre is located primarily along the main street (Williams Street) and adjacent streets bound by Cass Street and Ohoka Road	heavily affected town centre following the 4 September 2010 earthquake
Lyttelton Town Centre	Mixed business types. Lyttelton Town Centre is bounded by London Street, Dublin Street, Oxford Street and Norwich Quay	heavily affected town centre following the 22 February 2011 earthquake

The study was targeted at investigating the recovery of organisations in an urban setting. Therefore, the agriculture sector was excluded (see (Z.R. Whitman et al., 2011)) for detail on effects to the agriculture sector). With the resources available for the research, only a limited

number of sectors could be examined in detail. For instance, manufacturing and business services, even though they are high growth sectors, were excluded because of research resource limitations. These and other sectors could be investigated in future studies

However, it was identified that some of the sectors selected, e.g. ICT, had organisations that were involved with aspects of manufacturing or business services. In addition, the manufacturing sector is closely linked to some of the sectors selected such as trucking and retail. Analysing the trucking and retail sectors should provide some insights into some of the factors that might affect the manufacturing industry. The manufacturing sector also shares some commonalities with ICT as they are both export oriented.

Once the industry and geographic sector groups were selected, organisations were randomly sampled from within each sector (this was done by the researcher). The selected organisations share the main characteristic of being based in Canterbury and doing business in the region. As the organisations were from the entire Canterbury region, this means that the list includes organisations positively, negatively or not at all affected by the earthquakes. Part of the reason for this was to find out what different organisations had done differently before and after the earthquake and if this was a factor in how organisations were affected by and would recover from the event. Additionally, an individual sector had to be large enough that the conclusions formed would be applicable to the wider sector.

After review of the literature (Knight & Pretty, 1996; Lansing, 2003) and inspection of resource availability (time and funding), 100 organisations per sector was deemed a suitable sample size for each industry sector. This number would account for those who did not want to participate, for the attrition rate that is a part of any extended study and also allow for generalisations to be made about the sector. Also, for each of the 9 sectors sampled, giving a total of 900 organisations, 100 organisations per sector is also a manageable size given the available resources to conduct the study.

3.2 Industry sectors

3.2.1 Building suppliers

The building suppliers sector was selected because after the physical damage caused by the earthquakes; they would be involved in the repair, remediation, restoration and reconstruction

process of the built environment. Also, they are a good barometer for the performance of the construction industry sector as they have interactions with almost all levels of the sector. The starting sample list for the building suppliers sectors was from the Yellow Pages[15] 2010/2011. From this, every third organisation was selected until 100 organisations were on the list. The sample group included wholesale and retail building suppliers.

3.2.2 Critical infrastructure

Critical infrastructure is regarded as one of the cornerstones of recovery post-disaster. These organisations were included because of the essential services they provide to all other sectors in the region. Their inclusion was to investigate how the loss or disruption of critical services affects other sectors and also to investigate how this particular sector was affected. The organisation list for critical infrastructure was obtained from the endorsing agency[16] which has ties to the sector. The list was made up of 45 organisations and includes engineering and non-engineering critical infrastructure providers.

3.2.3 Fast Moving Consumer Goods (FMCG)

The Fast Moving Consumer Goods (FMCG) sector includes secondary food producers, supermarkets and dairies[17]. Apart from the intra-sectoral linkages, this sector has linkages with the trucking sector and these organisations are sellers of everyday consumables like milk, bread and other perishable goods which are part of consumer non-discretionary spending. The Food and Grocery Council of New Zealand (FGC) advised that there were four major branches (not listed for reasons of confidentiality) to this sector in Canterbury. Twenty-five organisations from each branch were randomly selected.

3.2.4 Hospitality (bars, cafes, restaurants)

Hospitality is a sector that comes under people's discretionary spending habits making it possible to track the discretionary spending habits of the general population and how this affects

[15] The New Zealand Yellow Pages are a directory listing for businesses

[16] Not named here for confidentiality reasons

[17] A dairy is the New Zealand equivalent of a corner store or a convenience store

recovery. It also has strong connections to the tourism sector which is a high-impact sector in the Canterbury region. Half (50) of the sample was from the Yellow Pages 2009/2010. The other half of the sample came from an internet list provided by the Central City Business Association (CCBA), along with their endorsement.

3.2.5 Information and Communication Technology (ICT)

Increasingly, organisations rely on some part of information and communication technology (ICT) to conduct their affairs. In addition, ICT is a high-growth sector identified as a key component of Canterbury's regional economic plan. The concentration of ICT firms in Canterbury leads to it being known as the Silicon Plains of New Zealand (after Silicon Valley in the USA). The starting sample list was provided by the Canterbury Development Corporation (CDC) after they had consulted the organisations on the list. The list had organisation names only. It was left to the researcher to find out the organisations' addresses and whom to address the survey to. A random sample of 100 was picked from the list provided using Microsoft Excel's random generator function.

3.2.6 Trucking

Trucking represents the transport sector but was specifically selected because they are part of the logistics chain for all the other industry sectors in the study. The trucking sector also has linkages with some of the other sectors selected for this study making it possible to observe how these sectors affected each other in recovery as well as how sectors not included in this study might be affected because of such linkages. The names and addresses for the trucking sector organisation were provided by the Road Transport Association New Zealand Inc. (RTANZ), in consultation with their members. The Association's endorsement was also obtained so as to help increase the response rate. A random sample of 100 organisations was picked from the list provided using Microsoft Excel's random generator function.

3.3 Geographic locales

Also strategically selected were specific geographic sectors not related to business type. The geographically selected groups were included based on their role in the Canterbury economy as well as because of their location to exemplify the importance of environmental context on organisational recovery. Additionally, the geographic sectors, with the existence of a large

number of organisations concentrated in one physical area, represent a system which has interactions between organisations from different industry sectors. As well, the geographic locations are economically and culturally significant to the regions they are in. These geographic locations were also severely affected by the earthquakes.

3.3.1 Christchurch Central Business District (CBD)

The central business district (CBD) is the economic hub of Christchurch[18], has some of the city's major tourist attractions and represents an aggregation of organisations in one locality. For this study, the Christchurch Central Business District (CBD) is defined as the area bound by the four Avenues: Bealey Avenue, Fitzgerald Avenue, Deans Avenue and Moorehouse Avenue. The organisations for the Christchurch CBD sample group were selected from a list of organisations within the Four Avenues. The final sample list was arrived at using stratified sampling by business type and by percentage of that business type on the starting list. This was in an effort to ensure proportional representation.

3.3.2 Kaiapoi Town Centre

Kaiapoi is a satellite town about 20kms north of Christchurch. Kaiapoi was one of the most heavily affected town centres following the 4 September 2010 earthquake. As well, it is also an aggregation of organisations in one locality. A sizeable proportion of the local population works in Christchurch city. The Kaiapoi Town Centre is the town's central business district and is located primarily along the main street (Williams Street) and adjacent streets bound by Cass Street and Ohoka Road. A list of organisations was provided by the recovery office formed after the 4 September 2010 earthquake. The cluster sampling method, i.e. all organisations were included, was used for Kaiapoi as the sample population was less than 100.

3.3.3 Lyttelton Town Centre

Lyttelton has the main port for the South Island of New Zealand and is connected to Christchurch by the Lyttelton Road Tunnel which is used for the transportation of imports and exports. Lyttelton is also known for its vibrant arts and crafts scene. Lyttelton Town Centre is

[18] Prior to the 22 February 2011 earthquake.

roughly bounded by London Street, Dublin Street, Oxford Street and Norwich Quay. For Lyttelton also, cluster sampling was used. The sample organisations for Lyttelton Town Centre were from a list provided by the town's business association.

3.4 Data collection

3.4.1 Research instruments and methods

In this thesis, the unit of analysis is the industry or geographic sector. However, the primary unit of inquiry, to enable data collection, is the organisation. This is similar to an investigation on community recovery collecting data from individual households

Data were collected using multiple methods; surveys, contextual interviews and case studies. The information from the surveys was augmented by information from semi-structured interviews conducted for the establishment of context and background with industry sector and business leaders. Data were also collected from case studies with selected organisations within the study sample group. There are several reasons for this combination of methods for data collection. The survey, sent in hard or soft copy, is less expensive than a telephone call or a face-to-face visit and it might be more convenient for the respondent as they can complete it at a time of their choosing. However, there are advantages to telephone or face-to-face interviews. The researcher is able to establish rapport with the respondent; he/she can amend and adapt the research questions as the interview progresses and can clear any doubt and misunderstanding by repeating or rephrasing the questions. In addition, the face-to-face interview allows the interviewer to observe the body language or facial expressions of the respondent. These can work as non-verbal prompts, which is of advantage to the researcher. The interviews also provide the opportunity for the researcher to ask for more in-depth information that would be difficult to collect using a survey.

The case study gives the chance to get more detailed information about specific organisations (Yin, 1989). Also, for small businesses, it has been shown that case studies done in conjunction with other research methods, yields a richer data set (Romano, 1989). This is in part due to each small business having a different management structure. The case studies were to supplement and add to the information already collected via surveys and contextual interviews. Part of the reason for this is that some qualitative, in-depth information is not as easy to obtain via survey

questionnaires as it is through interviews and even more, through case studies. Also, with the utilisation of case studies the researcher hears first hand from the organisations involved their description of occurrences before, during and after the event and specifically how the organisation dealt with the acute phase of the crisis as well as the aftermath. Additionally, it is important to understand the recovery of the individual organisations in order to understand the recovery of the industry sector. Table 3-2 shows the link between the research aims, research questions and the research methods and analysis that were used. More details of the methods analysis are in section 3.5.

Table 3-2: Research aims, research questions and research methods matrix

Research Aims	Research Questions	Research Methods and Strategies	Analysis
Investigate the major factors involved in the recovery of organisations after a major (regional) hazard event.	What factors - severity of the effects (direct and indirect) of a major hazard event, or the pre-or post-event performance - have substantial effects on the recovery of organisations and what are the relative magnitudes of these effects?	Questions contained in surveys, contextual interviews, case studies.	Grounded Theory, qualitative analysis, quantitative analysis, grand theory.
Determine the system dynamics involved in the recovery of organisations and sectors.	What are the system behaviours that contribute to the recovery of an individual organisation, a sector and between sectors?	Model or framework of the system, contextual interviews, case studies.	Principles of system dynamics.
Review the work done by Stephenson and McManus, enhance the Organisational Resilience Measurement Tool and contribute to the overall aims of ResOrgs.	Which of the indicators of organisational resilience are prominent in a regional disaster?	Case studies, Organisational Resilience Measurement Tool contained in surveys.	Grounded Theory, quantitative and qualitative analyses.
Explore ways of enhancing the (business) case for resilience.	What is the link between resilience and organisational performance?	Questions contained in surveys, semi-structured interviews, case studies.	Quantitative and qualitative analysis.

3.4.2 **Research timeline**

Richards and Morse (2007) note that data is not *collected* but rather is *made* through an interactive process occurring between researchers and participants. For this extended study participants were sampled at different times from the 4 September 2010 event through the various research methods mentioned. The research time line is shown in Figure 3-1.

Survey 1 was deployed a few weeks after the 4 September 2010 earthquake to capture information in the critical period just after a disaster has occurred. This was followed by Survey 2 which was deployed after the 22 February 2011 earthquake and was ongoing during the 13 June 2011 aftershocks. Contextual interviews were started while the second survey was underway. The case studies were begun after Survey 2 had drawn to a close and the bulk of the contextual interviews had been done. Survey 3 was deployed as the case studies came to a close. Each part of the research was informed by the preceding part which enabled the adjusting of the overall research plan to best answer the research questions. The case study research was an opportunity to establish a grounded theory (see section 3.5) toward answering the cardinal research question: How do organisations recover after disaster?

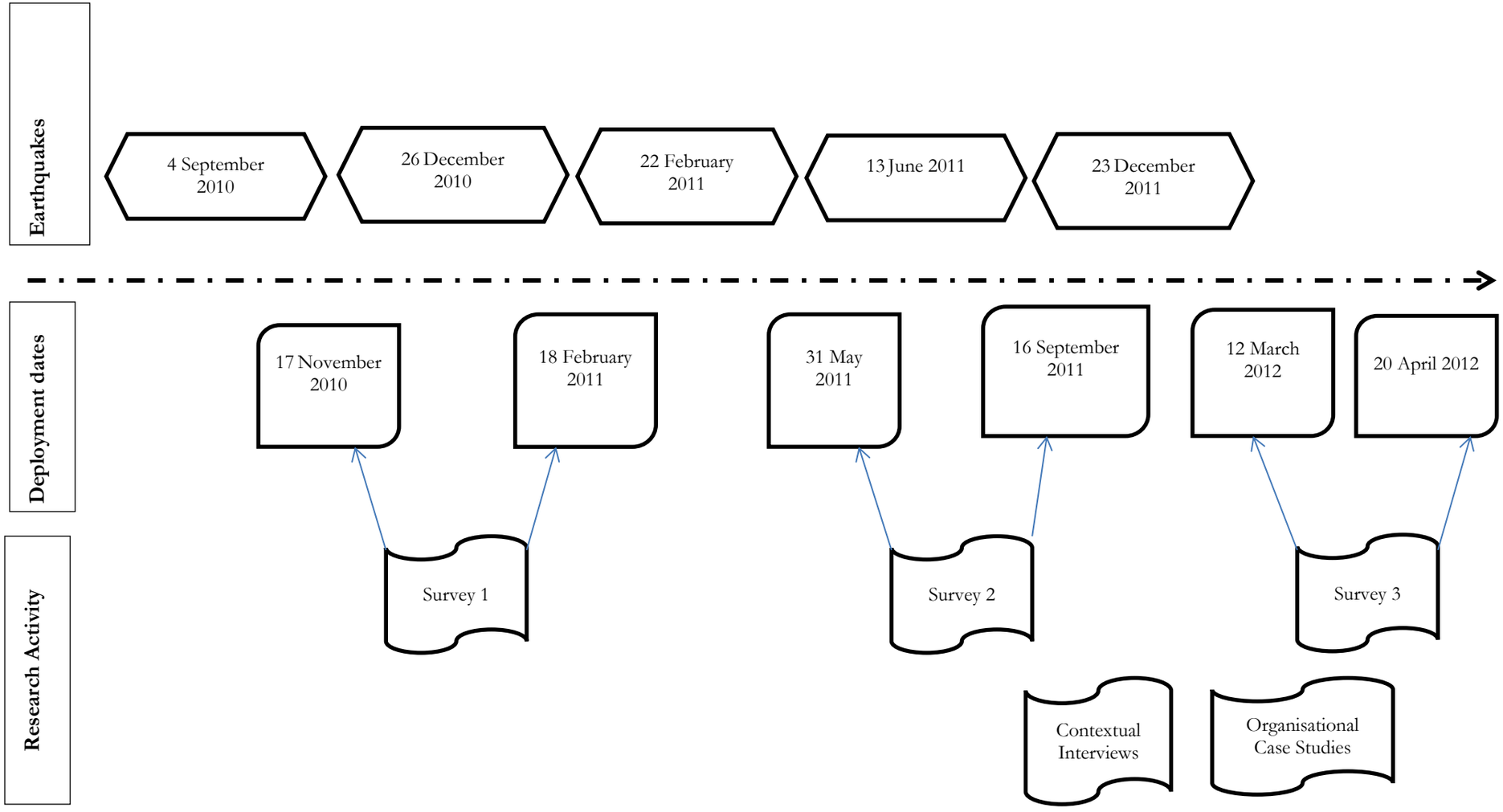


Figure 3-1: Research timeline for this thesis

3.4.3 **Surveys**

Surveys come in a wide range of forms and can be distributed using a variety of media (written, oral or electronic). As with all modes of research, surveys also have strengths and weaknesses. Several authors (e.g. (Prud'homme, 2008), (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007), (Jaeger et al., 2007), (Cruz & Steinberg, 2005)) have written on the pros and cons of using surveys as a data collection tool. Some of the strengths of surveys include their relative affordability and reach; they can be administered from remote locations using physical mail, electronic mail or telephone. It is also possible to administer a survey to a large population and the results can then be used to describe the characteristics of the general population. The standardisation of the questions in a survey makes measurement more exact because the questions use uniform definitions for each participant. This also means that similar data can be collected from different groups and the results compared.

Some of the weaknesses of surveys are that the standardisation of questions to make them applicable to a sample group means that some of the questions may end up being too general and not elicit the information sought. In addition, the initial survey study design cannot be changed over the course of the data collection period once the survey is deployed. Lastly, the researcher needs to ensure that a large enough number of respondents complete the survey especially for purposes of statistical validity and generalisation.

Survey deployment

After a review of the literature (Knight & Pretty, 1996; Richards & Morse, 2007), the research team concluded that 100 organisations per sector was a suitable sample size for an extended study of this nature. Firstly, this would account for the attrition, for instance through non-response, that is a part of a study of this length. Second, the number of respondents per group was also designed to allow the researcher to make generalisations about a particular sector.

To help with the initial deployment of the survey, research assistants (RAs) were hired. The RA positions were advertised through Student Job Search Canterbury which works in collaboration with the University of Canterbury. Each applicant was asked to send a CV and cover letter. One criterion for making the RA shortlist included that the applicant have a grade point average

(GPA) higher than 6.5 (as measured in New Zealand where the maximum is 9), or B+. Shortlisted applicants were invited to face-to-face interviews with a minimum of two interviewers from the research team present. Successful applicants were then invited to an information session on the aims of the research as well as to be told in more detail what the job entailed. The information session also included telephone etiquette to ensure uniformity among the RAs.

The survey used for this research was designed so that it could be completed by the respondent and could also be administered using different media. The multi-media format was to give respondents the flexibility to complete the survey at a time of their choosing. It was recognised that in some cases, the respondents might have no time to complete the survey for instance during regular business hours as they effected recovery for their organisation.

Organisations were contacted by telephone to establish who would be the right person to complete the survey on behalf of the organisation as well as how they would like to receive the survey. Respondents were then asked to give their preferred address; electronic or physical. The survey was then sent to the nominated person and a follow up call made a few days later to offer them the option of completing the survey over the telephone with a research assistant taking down the answers or a researcher meeting with them in person.

The survey used a paper based questionnaire that was sent out to participants via physical mail or electronically (as an attached text document in e-mail). Respondents also had the option of completing the survey online via the University of Canterbury's Qualtrics survey engine. All respondents who agreed to take part in the study were sent a survey cover letter detailing the nature of the research. The cover letters were tailored for the different sectors. In addition to a survey cover letter, organisations that opted to receive a physical copy of the survey were sent the survey booklet and a pre-addressed, pre-paid return envelope. Respondents that received the survey as an electronic document had the option of returning the survey in the same format or as a printed copy sent by physical mail.

Each survey contained 2 main parts, the *recovery* part and the *resilience* part. For recovery, the first survey (Survey 1) was deployed to capture perishable data while it was still somewhat *fresh* in respondents' minds. The survey included questions that asked about initial impacts and initial

perceptions of respondents soon after the 4 September 2010 event. Survey 2 was to gather more detailed information about ongoing effects and also included organisations from Lyttelton that were not part of the original sample group. This is because Lyttelton was relatively unaffected by the 4 September 2010 earthquake but severely affected by the 22 February 2011 earthquake. Survey 3 asked about continuing effects more than 18 months after the 4 September 2010 earthquake as well as effects due to the ongoing aftershocks.

For the questions on organisational resilience, Survey 1 contained a shortened (13 questions) trial version of the complete (53 questions) Benchmark Resilience Tool (BRT-53) developed from the work of Stephenson (2010) and McManus (2008). The reason for this was to test for the accuracy of predicting the resilience score using fewer questions from the tool in place of deploying a full version. Another reason was to keep the surveys to a reasonable length for participants. The results from this were compared to results of the BRT-53 deployed in Survey 2. Survey 3 also contained a shortened version of the BRT-53. The questions contained in the BRT-53 are in appendix F. The development of the shortened version of the BRT-53 is detailed in Whitman et al. (2013).

From the outset, it was acknowledged that the respondents would most likely suffer from survey fatigue as the number of researchers and organisations with an interest in the aftereffects of the earthquakes was large. Importantly, the nature of the subject was very emotive and somewhat invasive as this was to do with people's lives and livelihoods. To help increase the survey response, industry associations and other local bodies like the Canterbury Development Corporation (CDC) [19] were asked for their support and endorsement (see Table 3-3). Endorsements were included in the cover letters.

[19] CDC is funded by the economic development arm of the Christchurch City Council (CCC)

Table 3-3: Industry sector and endorsing organisation

Sector or Sub-sector	Industry Association or Endorsement
Building Suppliers	New Zealand Building Industry Federation (BIF)
Critical Infrastructure	Critical Lifelines and Infrastructure Group
Retail (FMCG)	Food and Grocery Council of New Zealand (FGC)
Hospitality	[20]
Information and Communication Technology (ICT)	Canterbury Development Cooperation (CDC)
Trucking	Road Transport Association NZ (RTANZ)
Christchurch Central Business District (CBD)	Christchurch City Council (CCC), Canterbury Employers' Chamber of Commerce (CECC)
Kaiapoi Town Centre	Enterprise North Canterbury (ENC)
Lyttelton Town Centre	Lyttelton Harbour Business Association (LHBA)

3.4.4 Semi-structured interviews

Semi-structured interview techniques were used for the contextual interview and case study phases. This is because it is not easy to capture in-depth answers to the *why* and *how* questions using only surveys. Additionally, although basic information such as demographic and social indicators were captured throughout the surveys, the questions more specific to organisational response and recovery changed over time the farther away from the event. Consequently, some of the contextual and case study questions were modified based on the answers to the survey questions. The interviews were conducted face-to-face with each interviewee. However, in two instances, the contextual interviews were done by e-mail due to the distance between the researcher and interviewee. Information from the interviews was also used to inform the qualitative part of the system dynamics models in this study.

[20] The team was advised that there were many associations within the hospitality industry which did not all have the same organisations as members. Further, not all hospitality organisations belonged to any association.

Kvale (1996) writes that the research interview is a particular type of conversation between interviewer and interviewee. The semi-structured interview approach allowed the researcher to consider a pre-specified list of areas of discussion with each interviewee. The time assigned to each area of conversation was left to the discretion of the interviewer. The open format of the semi-structured interview ensured that unexpected facts, attitudes or opinions could easily be further examined.

The semi-structured interviews were specifically tailored to the nature of the information sought, contextual or case study. However, each phase (contextual or case study) had a specific interview guide developed to ensure that the respondents were all asked the same basic questions. This was for the purposes of comparability later in the research and also to ensure that all topics of relevance were covered with each interviewee.

Contextual interviews

Each situation has background and context, so too the recovery of organisations after the Canterbury series of earthquakes. Contextual interviews were conducted with industry sector representatives, business leaders, experts on the Canterbury economy as well as those working with recovery agencies. The interviews were meant to enrich the information gathered via the quantitative portion of this research, to explore prevalent themes among the different industry sectors and to identify issues that transpired as recovery progressed.

The researcher called each interviewee to ask if they would participate in the research. A follow up e-mail was then sent to the interviewee with a brief description of the research and their involvement in it. The interview details (time and place) discussed on the phone were confirmed by e-mail.

The common question set designed for this phase of the study was modified dependent on the interviewee. Each interviewee signed an interview consent form which contained details of who was conducting the research and that everything they said was anonymous and confidential. At the end of each session, interviewees were asked if there was anyone else they thought the interviewer/researcher should speak with in relation to the research. All interviews were recorded and the researcher made extended field notes after each interview. Copies of the interview consent form and interview guide are in appendix A and appendix B. Further

treatment of contextual interview data will be described in section 3.5 on *data processing and analysis*.

Case studies

A re-analysis of the data from Surveys 1 and 2 as well as the contextual interviews provided the background context of this segment of the research. To start, all the organisations that had been contacted for Survey 2 were included in the long list as possible case study organisations. As the information from the case studies complement that from the survey and contextual interviews, it was decided that at least two organisations from each sector would be studied. Organisations were selected based on the criteria outlined below.

The criteria used in selecting the organisations included:

- → that the organisation had agreed to take part in further research after Survey 2;
- → at least two organisations from each sector and geographic area sampled;
- → if possible, at most three people from each organisation;
- → different size organisations (by employee number);
- → possible supply chain or locational relationships between some of the organisations, this to enhance the system dynamics analysis and to establish the effects of disruption to supply chains;
- → organisations with different ownership structures (e.g. sole owner, franchise); and
- → the organisation's resilience score based on Survey 2 (if possible one high and one low resilience scoring organisation, using the BRT-53, from each sector or geographic location).

Eighteen case study organisations were selected based on the criteria outlined. In total, 26 interviews were conducted. A maximum of three (qualitative) semi-structured interviews with different people were conducted with each organisation selected for this part of the study. Bertaux (2002) advises that 15-20 interviews are sufficient for qualitative research in general while Morse (2005) and Creswell (2010) write that 30-50 interviews are sufficient for the formation of a grounded theory. Where possible, the interviewees were from different departments in the organisation to give a fuller picture of events before, during and after the

crisis in relation to their organisation. The primary organisation contact, based on Survey 2 information, was asked to recommend other interviewees who would contribute to the study and provide an alternative organisational perspective. In addition to the two organisations selected from each sector, there were two other back-up organisations in case the primary organisations declined to be interviewed.

Interviewees were first contacted by telephone and reminded of previous participation and contribution to the research. They were then asked if they would be willing to participate in this part of the study. The researcher explained the case study process and asked what dates were suitable for the interviewee. The interviewees were then sent an e-mail with the interview date and other details. The researcher met each interviewee at a location of their choosing; this was usually the organisation's premises for those organisations that had returned to their premises or alternative locations if the organisation were working from elsewhere. When possible, the interviews were conducted back-to-back for each organisation so that organisational information from one interview to the next was still fresh in the interviewer's mind. All interviews were recorded using an audio recorder. This was with the interviewee's permission who also signed interview consent and agreement forms.

Prior to interviewing the first participant, an interview guide with interview questions was developed. This was to ensure that the same topics were covered with all participants (please see appendix H for the interview guide). The guide was roughly divided into three main parts:

→ pre-crisis;
→ during the crisis; and
→ post-crisis.

Two further supporting parts of the interview guide contained specific questions on what the interviewees thought of the resilience and recovery of organisations after disaster. In the interviews, the first few questions were to establish the organisation's background (financial position, pre-crisis experience) and also served to put the interviewees at ease. The questions that followed were not always asked in the order in which they appear in the interview guide, this was dependent on answers given by the interviewee.

3.5 Data processing and analysis

The analysis of the data is tailored to the research aims and questions as demonstrated in Table 3-2. In this thesis, grounded theory (Glaser & Strauss, 1967) is used for theory development. In the grounded theory method, the theory emerges from the data collected. To a limited extent, grand theory will also be used as it involves the prior formulation of theory as well as deduction and testing. The prior formulated theory is based on the literature on disaster recovery, organisations and crisis management reviewed earlier. It has been suggested that both theories should be used in tandem as they are normally involved in research and it is difficult to separate the two (Eisenhardt & Graebner, 2007). Additionally, Suddaby (2006) writes that the developers of grounded theory did not intend to replace the grand theory method but rather to complement it.

3.5.1 Grand theory

A lot of research is designed not to generate new theory but to verify existing theory. This means that findings are arrived at through logical deduction from past studies and knowledge and not from the data itself. For instance, in the disaster research literature some studies that fit this mould include those by Toder and Allen (2004), Corey and Deitch (2011) and Dahlhamer and Tierney (1996).

This way of conducting research is often referred to as the grand theory research method which, according to Skinner (1990), was developed by Mills (1959). Perz (2007) goes on to describe grand theory as having global, abstract concepts while Merton (1967) criticised the abstractedness of grand theory as a disadvantage when making the link between theory and observed phenomena. Merton argues that this disadvantage stemmed from grand theory not providing sufficient direction in how data for particular theories should be collected. In this thesis, grand theory will be used only to a limited extent.

3.5.2 Grounded theory

The grounded theory research methodology was developed in 1967 by Barney Glaser and Anselm Strauss (1967). It is a systematic methodology involving the discovery of theory through the analysis of data (Martin & Turner, 1986). According to Strauss and Corbin (1990, p. 23), a

grounded theory is *one that is inductively derived from the study of the phenomenon it represents*. Additionally, in the literature the term grounded theory is used for both the process and outcome i.e. using the grounded theory research approach leads to a theory grounded in data. From the extensive works on the grounded theory approach, it can be deduced that the stages for the process involve:

→ Identification of the area to be studied: the study is carried out via the perspective of people involved in the area e.g. interviewees in disaster affected organisations

→ Collection of data: the data for grounded theory can be qualitative or quantitative.

→ Simultaneous collection and open coding of data: in the grounded theory approach, these are integrated activities. Strauss and Corbin (1990, p. 96) further proposed axial coding which is *a set of procedures whereby data are put back together in new ways after open coding, by making connections between categories*. They proposed a *coding paradigm* comprising *conditions, context, action/ interactional strategies and consequences* (Strauss & Corbin, 1990, p. 96).

→ The writing of notes or memos in relation to the coding: from this the main dimensions and their sub-themes develop. Pidgeon and Harwood (1996) describe memo writing as the externalisation of data analysis and that it enables further theorising.

→ Selective coding of data: after the main dimensions and sub-themes have been identified, coding is carried out for these main dimensions and sub-themes only. Further sampling is then directed by the theory being developed and is used to enhance and corroborate the main dimensions and sub-themes.

Several authors point to the advantages of using the grounded theory approach (see e.g. (Borgatti, 2004; Charmaz, 2003; Cutcliffe, 2000; Turner, 1981)). Some of the advantages include the possibility of using simultaneous inductive and deductive thinking; the approach is open yet structured in how it allows researchers to explore themes; and its emergent nature allows for analysis of how different parts interact as opposed to only studying specific variables. Lastly, Turner (1983) illustrates how grounded theory can be used in organisational research because of organisational complex social interactions, while Eisenhardt (1989) points out that the emergent properties of the grounded theory approach are ideal for use in case study analysis and cross-case comparisons.

Interestingly, Strauss and Corbin (1990) characterise two levels of theory generated when using the grounded theory approach: grand theory and substantive theory. Grand theory evolves from exploring a phenomenon in a variety of contexts, for example the study of disaster recovery in organisations from different sectors. From the description of grand theory in section 3.5.1, the different contexts of recovery can include determining factors of recovery after different disasters. Substantive theory on the other hand is derived from the study of phenomena situated in a particular situational context. In this research, this is equivalent to the study of disaster recovery in an individual organisation.

3.5.3 System dynamics modelling

For this thesis, system dynamics principles are used in analysis (see chapter 2 for detailed description of system dynamics). Systems thinking and system dynamics are used to analyse the system attributes (organisational, inter- and intra-sectoral) that are involved in recovery after a major hazard event. This is done using causal loop diagrams (CLDs) and stock and flow diagrams from system dynamics. Input information for the system dynamics modelling was obtained from both the quantitative and qualitative portions of the research. The system dynamics principles work well with the diagramming that is part of the analysis in grounded theory used in analysing the semi-structured interview. The inputs to and outputs from the system were examined to determine the system's behaviour. System dynamics modelling is iterative and has five key steps (Sterman, 2000) shown in Figure 3-2.

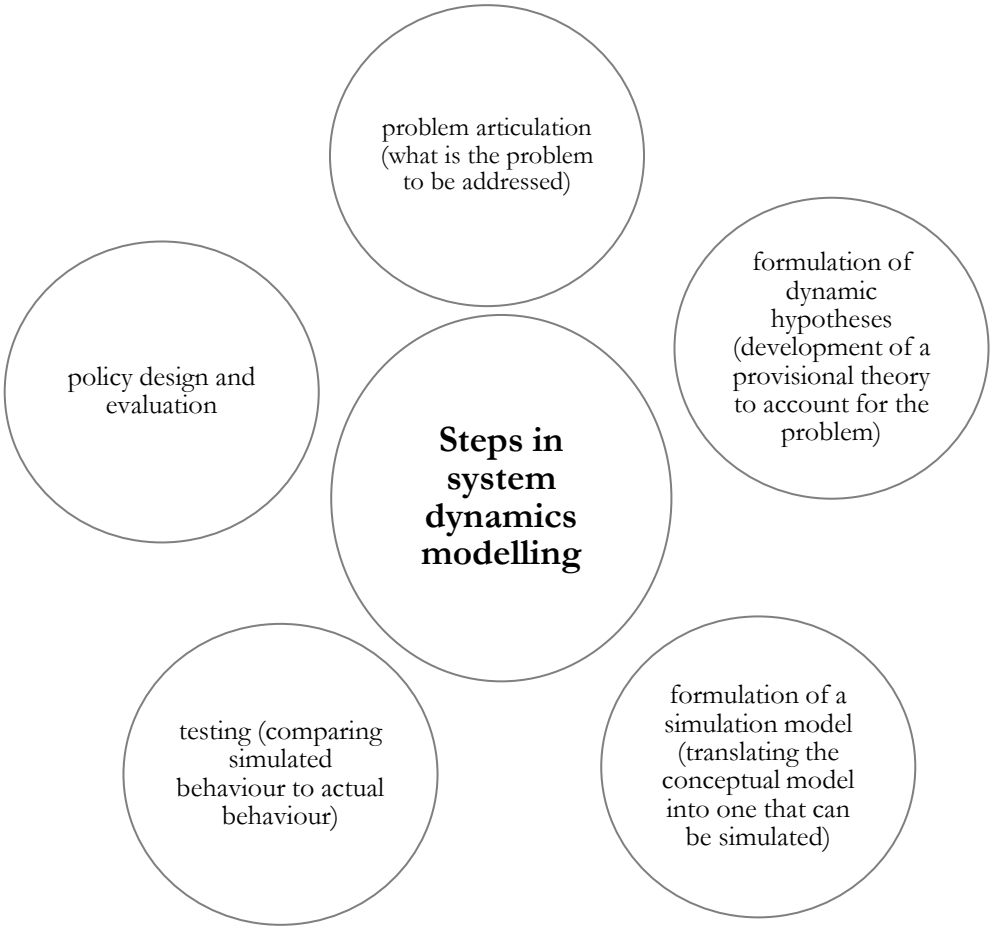


Figure 3-2: Steps involved in the iterative steps of system dynamics modelling

The conclusions in any of these stages in Figure 3-2 can be used to make modifications and improvements in any of the other steps. Of the five key steps of system dynamics modelling, this thesis makes use mainly of the first three: problem articulation, formulation of dynamic hypotheses and formulation of a simulation model. In problem articulation, the purpose of the system was stated and led to the definition of the system and its environment. In this stage also, the causal loop diagramming was started. The earlier causal loop diagramming was an aid in visualising what the system contained. The causal loop diagrams were updated continuously throughout the research as new information and insight became available. In step 3, formulation of a simulation model, the causal loop diagrams were converted to stock and flow diagrams and quantified.

The numerical output from the quantification of the stock and flow diagrams are included in appendix J, however, the results from this are inconclusive. There are two main reasons for this. First is that additional data and analysis, beyond the scope of this thesis, are required to carry on

the simulation from the quantified stock and flow diagrams. Second, the time horizon for data collection may have contributed to the inconclusive results as the medium-term effects of recovery were not yet manifest. As a result of inconclusive results from the quantification and simulation of the stock and flow diagrams, step 4 in Figure 3-2 (testing) was not much utilised. This thesis did not outline the policy design and evaluation in step 5. However, the aids, hindrances and point of intervention in recovery (see chapter 9) resulted from examination of the causal loop and stock and flow diagrams. Part of the reason for not outlining comprehensive policy is that the time horizon of this research falls within the first two years after a disaster event. The design and evaluation of recovery policy would be more beneficial incorporating a longer time period, as is suggested in the future work section in chapter 11.

There is particular notation used in system dynamics modelling. CLDs are used in the initial phases of modelling to represent the information gathered and to help articulate the problem. An example of a CLD is shown in Figure 3-3. The figure has elements and causal links (the arrows). Each causal link has a sign (polarity) showing the effect one element has on another. Positive polarity, e.g. between *deficit in organisational and sectoral throughput* and *organisational or sectoral recovery measures and programmes* means that as the element at the tail of the arrow changes, it produces a change in the element at the head of the arrow in the same direction. Negative polarity, e.g. between *organisational and sectoral throughput* and *deficit in organisational and sectoral throughput,* means that as the element at the tail of the arrow changes, it produces a change in the element at the head of the arrow in the opposite direction. The feedback loop, B, represents a negative feedback loop which means the system depicted is goal seeking. Causal loop diagrams are especially useful in articulating a problem and visualising complex interactions between numerous system components. Additionally, causal loop diagrams are the foundation upon which stock and flow diagrams are built so that the behaviour of the system can be observed over time. Figure 3-4 shows a stock and flow diagram. A stock is anything that accumulates or depletes over time while a flow is the rate of change of a stock. *Inflow* adds to the stock while *outflow* depletes the stock. The arrows from *Stock* to *inflow* and *outflow* show that there is an exchange of information between the stock and the flows which can contribute to the rate of the flows. The clouds on the ends of the flow arrows depict the environment of the system.

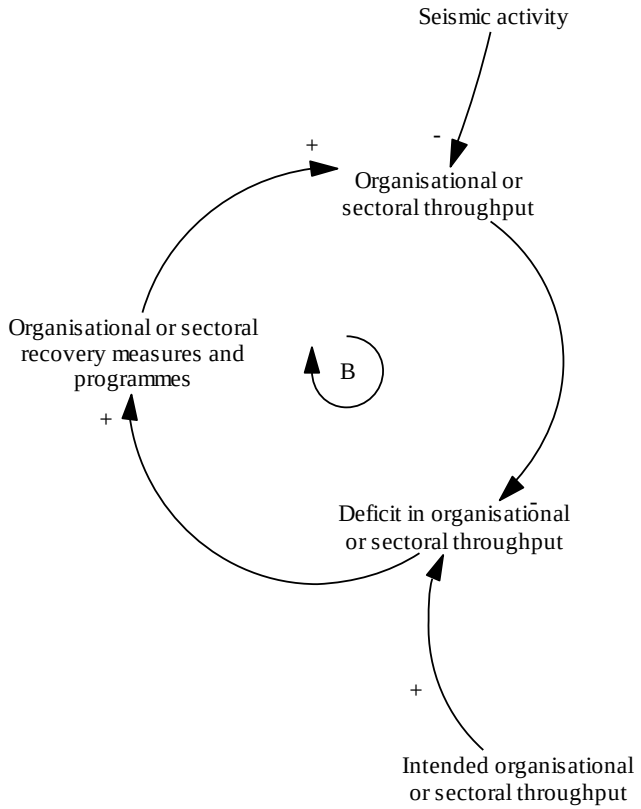


Figure 3-3: Illustration of a system dynamics causal loop diagram of organisational or sectoral recovery

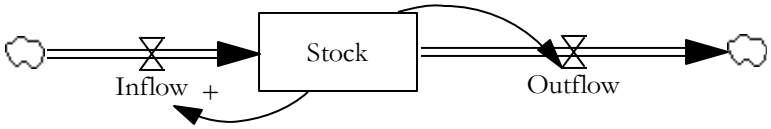


Figure 3-4: Illustration of a simplified system dynamics stock and flow diagram with inflow, outflow and information links

The stock is the rectangle and captures the idea of quantity at any one time. Stocks are elements that can be filled or depleted over time. For instance, the health of the economy at any instant is a stock. Flows add to or subtract from a stock; the inflows are the arrows flowing into the stock (e.g. economic growth), while outflows are arrows pointing away from or draining the stock (e.g. economic decline). The valves on the flow arrows act as flow regulators and the clouds are sources or sinks (and are outside the system boundary). The stock changes only through the inflow and outflow valves. Stock and flow models can also have auxilliary variables which are system elements that modify the flows into or out of stocks.

One way to conceptualise stocks and flows is to think of a stock as a bathtub with the taps acting as valves of flows regulators into the bathtub and the drain as a flow regulator out of the bathtub. The water represents the flow.

3.5.4 Data preparation

To prepare the contextual interview and case study data sets for analysis, the recorded interviews were uploaded to a secure computer. As opposed to analysing the interview transcripts after all the interviews had been done and the audio files transcribed, a preliminary analysis of each interview was done following its completion and in advance of the next interview. One way of doing this involved the writing from memory of extended notes after each interview.

The audio files were then delivered to a professional transcription agency for transcription. The use of a professional transcription agency was one part of interview transcription reliability; that what was contained in the audio files was what was in the typed copy. The agency manager signed a transcriber confidentiality form on behalf of the agency. The transcriptions were verified for accuracy by the interviewer or researcher re-listening to them while reading the transcription. One benefit of this was that the interviewer became even more familiar with the content while at the same time correcting any errors made by the transcriber. Each interviewee was asked if they wanted the interview transcript sent to them for verification. All the interviewees declined.

The contextual interview information provided an overview of the circumstances for each particular sector and for the Canterbury region. This information set the scene for some of the case study questions as it detailed sectoral pre-disaster trends and some of the interactions in the regional economy. For the case studies, within-case and across-case analysis is employed. This is in addition to the within-group analysis done for each sector and location using the survey results. Following the reading of the transcript several times for familiarisation, the data are coded at first manually and then later using NVivo9 qualitative analysis software into main dimensions and their sub-themes. In the case study literature, Meadows and Morse (2001, p. 194) point out that a combination of different analytic approaches e.g. constant comparison, immersion or crystallisation, matrices, manual analysis, and computer-assisted analysis can enhance and enrich a study.

In describing the main dimensions or concepts of the data, the researcher came up with appropriate phrases (some drawn from the literature) or occasionally used the interviewees' words. The main dimensions (see chapter 6) became the nodes in NVivo9 while the sub-themes became the sub-nodes. The analysis of each interview after it was conducted was also partly used for the corroboration and expansion of the initial ideas and theories extracted from the earlier interviews.

For the more detailed analysis, a modified version of Strauss and Corbin's (1998) coding paradigm was used. The paradigm outlines a logical way of gathering and ordering concepts as well as a way of grouping similar data. This paradigm corresponded very well with the different parts defined in the interview guide and with the systems thinking approach. This is mainly because both system dynamics and grounded theory use the interactions between variables from which the theory or the concepts are generated. The paradigm has three components into which concepts are arranged. These are presented in Table 3-4 alongside their corresponding component from the case study interview guide and from systems thinking.

Table 3-4: Comparison of the grounded theory paradigm, the case study interview guide used in this thesis and systems thinking concepts.

Grounded Theory Paradigm	Case Study Interview Guide	Systems Thinking Concepts
conditions, the conditions that create situations relating to a phenomenon	pre-disaster conditions	conceptualisation of system to analyse interaction between agents
actions/interactions, the ways in which persons deal with the situations encountered	acute phase of the crisis/disaster	investigation of the change in dominance of feedback loops and system behaviour during crisis
consequences, the outcomes of actions/interactions	post-disaster effects	further investigation of change of dominant feedback loops and interactions between system actors over time

The coding of the data was helped by thinking of and using the principal theme of the research which was *the key elements of recovery for organisations and sectors after disaster*. Therefore, all of the dimensions identified and coded related back to this main theme.

3.6 Chapter summary

This chapter discusses the reasons for the selection of the different sectors included in this study. There is also an analysis of the methods which are used as the basis for the collection and analysis of data. It was shown how the design of the research should be coupled with the

methods used to gather data and to analyse it. The methods to be used are drawn from different fields: mainly grounded theory and system dynamics and to a limited extent from grand theory. These methods complement each other and are useful for investigation and analysis of sectoral and organisational disaster recovery.

The next chapter has a background description of the sectors included in this study. The description includes some of the conditions surrounding the individual sectors prior to the earthquakes and how such conditions may influence the way the individual sectors were affected by the earthquakes.

4 Contextual interviews

This section presents results from the contextual interview part of the research. The aim is to provide background information for the climate the affected organisations and sectors operated in both prior to and after the earthquakes in Canterbury. Contextual interviews were with business and industry leaders, individuals knowledgeable about the economies of Christchurch, Canterbury and New Zealand as well as people working with recovery agencies. The interviews are also meant to enrich the information gathered via the quantitative portion of this research, to explore prevalent themes among the different industry sectors and to identify issues that transpired as recovery progressed. In some cases, the interview responses also act as a guide for some of the questions crafted for the surveys. Organisations that participated in the contextual interviews are shown in Table 4-1.

Findings from the contextual interviews are presented in three main parts. The first part is an overview followed by a brief discussion of each sector in the study. After this is a short discussion on the acute phase after the earthquakes and how some of the sectors were affected. The chapter closes with a presentation of the main themes, common to the sectors, which arose post-disaster.

Table 4-1: List of contextual interview organisations and brief descriptions

Contextual interview organisation	Brief description
New Zealand Building Industry Federation (BIF)	represents the supply web of the building industry
Canterbury Communities' Earthquake Recovery Network (CanCERN)	network of Residents Association and Community Group representatives from the earthquake-affected neighbourhoods of Canterbury
Canterbury Earthquake Recovery Authority (CERA)	lead recovery agency after the Canterbury earthquakes
Canterbury Employers Chamber of Commerce (CECC)	largest business support agency in the South Island of New Zealand
Canterbury Development Corporation (CDC)	economic development agency for the Christchurch City Council
Canterbury Business Leaders Group (CBLG)	forum of business leaders representing substantial investment and commercial interests in the Canterbury region
Canterbury Lifelines Utilities Group (CLUG)	non-statutory organisation comprising territorial local authorities (TLAs) and commercial utilities operating in the region, research organisations and emergency services
Canterbury Software Cluster	non-profit organisation aimed at helping the Canterbury software sector succeed in New Zealand and globally
Central City Business Association (CCBA)	works with local authorities and acts as a conduit to the businesses, property owners, stakeholders and other interested parties
Christchurch City Council (CCC)	second largest district council in New Zealand. Responsible for the Christchurch City, Sumner, Lyttelton, Banks Peninsula and Akaroa.
Enterprise North Canterbury (ENC)	business association for North Canterbury region (Waimakariri and Hurunui Districts)
Food and Grocery Council of New Zealand (FGC NZ)	industry association representing the manufacturers and suppliers of New Zealand's food, beverage, and grocery brands
Hospitality Association of New Zealand (HANZ)	voluntary trade association representing 2,400 hospitality businesses
Lyttelton Harbour Business Association (LHBA)	provide area businesses with a commercially oriented platform for the support of economic development within the Lyttelton Harbour area
New Zealand Hotel Council (NZHC)	incorporated society whose members include the international chain, independent, privately-owned and boutique hotels throughout the country
Road Transport Association New Zealand Inc. (RTANZ)	represent the interests of road transport operators
Waimakariri District Council (WDC)	district council for Waimakariri

4.1 Contextual interview overview

Interviewees were asked to identify the economic or geographic advantages of operating from Christchurch pre-4 September 2010. Interviewees noted that, as New Zealand's second largest city, Christchurch has the largest population in the South Island and was a growing market prior

to the earthquakes. Other advantages for business were that Christchurch is the hub of and gateway to the South Island, the proximity to Lyttelton port and Christchurch airport for import and export as well as the proximity to primary producers. Having Christchurch as a hub with its sea and air ports cut down on transportation and logistics costs for many of the sectors. Except for most of the standalone organisations in the hospitality sector, Christchurch is the primary hub in the South Island for the rest of the sectors in the study; where they run their South Island operations and distribute or provide goods and services to the rest of the South Island. Respondents reported that apart from commercial reasons, Christchurch is attractive to their staff for the lifestyle it affords them: the proximity to the sea, the mountains and nature.

Interviewees narrated that the response phase was characterised by a great deal of uncertainty as people tried to comprehend what had occurred. In the midst of all this, there was a lot of information that had to be made sense of. However, the general consensus was that communication from relevant authorities and agencies during the response phase was not as good as it could have been. Sector representatives reported that information was not timely, at times not relevant and details remained unclear. For instance, building suppliers state that there were too many messages from too many agencies regarding temporary housing which made it difficult to decipher what was required of the sector.

From contextual interviews, none of the industry sectors reported having previously faced a disaster of the magnitude caused by the earthquakes. Prior to the earthquakes some sectors such as building suppliers, the Christchurch CBD and hospitality were not in the best financial health (see sections 4.2.1 and 4.2.4 for details). This affected their organisation's financial situation, e.g. with reduced sales and cash flow, in the time after the earthquakes. Further, interviewees characterised *recovery* for their sectors as a return to pre-earthquake levels of revenue or better. Additionally, several contextual interviewees reported that their sector had identified opportunities after the earthquakes that were new or that were thought about prior to the earthquakes and could be incorporated into a future rebuild strategy. However, sectors reported that identifying the right people to speak with about their ideas was not easy. A lot of time and energy was *wasted* being passed on from one agency to the next. As the recovery period progressed, interviewees detailed how the plan for the recovery of greater Christchurch was not clear. Particularly affected were trucking, hospitality, building suppliers and Christchurch CBD.

From the overview of the sectors, inter-sectoral linkages are apparent. These will be explored fully in chapter 8 where the system dynamics of recovery are discussed.

4.2 Industry sectors

4.2.1 Building suppliers

Building suppliers were selected for this study on the basis of their being a gauge for activity in the construction industry. This is because they have contact with all other parts of this industry. The building suppliers sample group in this study is comprised of wholesale and retail organisations. These are organisations representing the spectrum of building suppliers: some of the suppliers deal in building machinery, others in light manufacturing and yet others in building products and construction materials.

According to Careers New Zealand (2011a), the construction industry was the fifth largest in the country, accounting for eight per cent of economic output. Careers New Zealand also added that the residential rebuilding part of the sector was struggling. Meanwhile, the New Zealand Institute of Economic Research (NZIER) in their August 2010 outlook predicted that the commercial part of construction would *collapse* (New Zealand Institute of Economic Research, 2010). This outlook was based on the number of building consents applied for in the time leading up to this information release. This shows the state of the both the residential and commercial parts of the construction industry prior to the 4 September 2010 earthquake was poor.

The industry sector representative interviewed narrated that for each new house built, there is a multiple of three jobs created inside and outside the construction sector. Consequently, an important aspect that also needed to be looked at in the construction sector, after the earthquakes and prior to the larger part of the rebuild commencing, was the shortage of tradespeople (e.g. tillers, plasterers and plumbers). Chang-Richards et al. (2012) detail some of the challenges of resourcing in the construction industry after disaster.

Pre-earthquakes, building suppliers were affected by the recession in the construction industry and were running at about 60% less than their full capacity (industry sector representative, personal correspondence, 2011). This led to a lot of competition for work within the industry

prior to the earthquakes. The effects of the earthquakes then increased pressure on already tight profit margins. The sector was most affected after the earthquakes by the uncertainty of when the rebuild would start and what would be required (what kind of materials and in what quantities). Part of the uncertainty can be attributed to the long, unprecedented delays in the settlement of insurance claims caused by the unclear regulations surrounding rebuild and repair of properties on liquefiable soils. At the time of interview, a few months after the 22 February 2011 earthquake, the sector was optimistic but admitted that the uncertainty made it difficult to plan organisational strategies. This is in contrast to findings after other disasters (see Durkin (1984) and Tierney and Webb (2001)) where construction and manufacturing were more likely to recover in the short-term after disaster than service or retail organisations.

4.2.2 **Critical infrastructure**

The New Zealand Ministry of Civil Defence and Emergency Management (MCDEM) defines critical infrastructure providers, also known as lifeline utilities, as *entities that provide essential infrastructure services to the community such as water, wastewater, transport, energy and telecommunications. These services support the life of our community and are enablers of businesses, and underpin the functioning of the public sector social economy* (New Zealand Ministry of Civil Defence and Emergency Management, 2012). The utility companies in Christchurch are also voluntary members of a non-statutory body, the Canterbury Lifelines Utilities Group (CLUG). The CLUG was formed after the completion of the Christchurch Engineering Lifelines Project which culminated in the publication of the text Risks and Realities (Canterbury Engineering Lifelines Group, 1997). The project involved critical infrastructure organisations working together to identify network vulnerabilities. This information was used in carrying out the strengthening and reinforcement of infrastructure in the mid-1990s. Members of CLUG reported that they have benefitted from their longstanding networking efforts as utility and non-utility critical infrastructure service providers.

This sector was severely affected by the earthquakes in part due to the nature of their assets (e.g. buried infrastructure vulnerable to ground motion) and suffered a loss of capital value as a consequence of damaged infrastructure. They detailed that they recognised the value of the services they provide to their customers and that theirs is a different level of expectation and performance compared to other businesses. Rose and Lim (2002) discuss how business losses

can be exacerbated by dependency on lifeline services and the length of disruption to those services. For instance, petroleum and manufacturing are heavily dependent on electricity while this is not the case for construction.

According to the critical infrastructure sector representative, the most affected critical infrastructure organisations were the ones that deal with wastewater as their buried infrastructure suffered the most damage from ground shaking and liquefaction. Conversely, some of the other critical infrastructure providers detailed that the costs of repair to damaged infrastructure after the earthquakes would have been much higher had the seismic retrofit (e.g. of transformers) of the mid-1990s not been done. As a results of the pre-earthquake retrofit, critical infrastructure providers calculated that the savings made are approximately 90% of what the post-earthquake repairs would have cost (Canterbury Engineering Lifelines Group, 2011).

Some of the utility infrastructure is tightly coupled and interdependent, for instance electricity, wastewater and gas lines in close proximity to each other and also sometimes dependent on each other for operation. As a consequence, utility providers worked closely after the earthquakes to share best practice and discuss what further improvement measures could be undertaken to strengthen their networks. They recognised that the types of assets they own are not renewed often. Consequently, repair and remediation after the earthquakes should be used to implement newer standards and technologies that can withstand multiple hazard events.

4.2.3 **Fast Moving Consumer Goods (FMCG)**

The FMCG sector in this study comprises manufacturers (secondary producers), suppliers and retailers (e.g. supermarkets and dairies) of consumables. Some of the manufacturers and suppliers are part of larger multinational companies. Additionally, there are two organisations that own the majority of the supermarkets in New Zealand (supermarket representative, personal correspondence, 2011). Both organisations own supermarket chains that cater to different market segments from low end to high end. A dairy is the New Zealand equivalent of a corner store or convenience store and is usually privately owned. However, petrol (gas) stations usually also have a retail consumables area similar to a dairy.

In interviews FMCG manufacturers, suppliers and the supermarket chains all described having major distribution centres in Auckland and Christchurch. The Auckland distribution centres receive the bulk of shipped goods, service the North Island and also send goods to the South Island. The Christchurch distribution centres, some of which receive goods from the North Island, service the South Island. Apart from the convenience of having major distribution centres in Christchurch, some organisations spoke of very high transport and storage costs if they did not have their own distribution centres on the South Island.

The FMCG sector was in good financial health pre-earthquakes. Sales initially dropped considerably just after the earthquakes but this did not last long as most of the organisations in this sector produce and provide goods essential to sustain life. This sector was particularly affected by the disruption to utilities however. Further, as a consequence of dealing with putrescible products, the FMCG sector was faced with a massive clean-up job after the earthquakes due to shelving collapse and the need to dispose of stock. Also, the size and access to resources of most of the FMCG organisations in the sample meant that they were in a position to assist other organisations such as the Red Cross by donating food items.

4.2.4 **Hospitality**

The hospitality organisations in the sample are specifically cafes, bars and restaurants: organisations subject to customer discretionary spending. In the five years leading up to the 4 September 2010 earthquake, the hospitality industry in general had been affected by the global financial crisis. Visitor numbers to New Zealand were down and New Zealanders also cut back on their discretionary spending (Careers New Zealand, 2011b). However, in a July 2011 release, Statistics New Zealand (Statistics New Zealand, 2011d) reported that the highest increase in electronic card transactions for the year ending July 2011 was in the hospitality industry. However this information from Careers New Zealand and Statistics New Zealand is unclear. This is because the information is not presented by region, includes hospitality accommodation organisations and could be partly attributed to bookings for the 2011 Rugby World Cup which was hosted in New Zealand. For the year to February 2012 however, the largest decrease in electronic card transactions was in the hospitality industry (Statistics New Zealand, 2012d). This reflects the drop in customer discretionary spending which Statistics New Zealand reported was partly attributable to customers not spending as much in the uncertain economic climate. In past

disaster studies, Tierney (2007b) found that businesses dependent on customer discretionary spending may struggle to recover after disaster as people spend less.

Interviewed representatives from the hospitality industry reported that pre-earthquakes, the sector had been over-licensed, i.e. operational licenses, for an area the size of Christchurch. What is unclear is whether cafes were also over-licensed. The hospitality sector also had a high staff turnover pre-earthquake as a consequence of the decline in sectoral performance and the low wage structure common in the industry (New Zealand Department of Treasury, 2002). Pre-earthquakes, hospitality organisations located in or near the Christchurch CBD benefitted from the proximity to other businesses as well as from the visitor numbers to the CBD's tourist icons. Others hospitality organisations also had a steady custom from the people who worked in the CBD. These advantages became disadvantages after the earthquakes as some organisations whose premises were not damaged had to close due to the cordoning off of the CBD or of nearby buildings. For some hospitality organisations, their equipment was subject to direct physical damage and in other instances was not easily moveable which made relocation difficult.

4.2.5 Information and Communication Technology (ICT)

Information and Communication Technology (ICT) was identified in the Canterbury region's economic strategy as a high-growth sector (Canterbury Economic Development Co. Ltd., 2009) and is second only to dairy in export earnings (New Zealand Information and Communication Technologies Group, 2010). Additionally, the Canterbury Development Corporation (personal correspondence, 2012) regards ICT as a pull sector. Nemet (2009) describes a pull sector as one where demand for goods and services is a principal driver for the rate and direction of innovation. This description corresponds to the reported rise in demand for ICT services from organisations affected by the earthquakes. Despite this, the sector reported facing a shortage of skilled personnel before the earthquakes. The sector thought that this trend would be exacerbated by the earthquakes as a lot of expatriate ICT personnel were thinking of leaving the region.

The interviewee reported that a significant number of ICT organisations in New Zealand are export focused. However, a small proportion of ICT organisations serve the local market for activities such as server installation, maintenance, data management and programming. For this

proportion of ICT organisations the earthquakes brought with them an increased workload. There was a surge in requests for data retrieval and for the migration to newer methods of data management such as cloud computing. ICT has become a core part of the operations of many organisations and for them to get back up and running as quickly as possible their ICT systems had to be functional.

4.2.6 **Trucking**

The National Road Carriers Inc. (NRC) reported that more than 90% of New Zealand's freight, by weight, is transported by road (National Road Carriers Inc, 2012). This is consistent with the information from FMCG organisations who stated that a significant portion of their goods are transported in this way and illustrates the level of interdependency between these two sectors. Apart from those trucking organisations working with FMCG, other trucking organisations work closely with the construction industry while others are involved in cross-country transportation of goods.

A characteristic of the trucking industry in New Zealand is that trucking organisations pay road user charges based on the weight of the goods they carry and also on the distance their vehicles travel (New Zealand Transport Agency, 2012b). This means that it is in their interests to transport goods in the shortest distance possible. Trucking organisations reported that after the 22 February 2011 earthquake, they faced increased costs from more time on the road due to reduced road capacity, increased distance caused by detours, as well as from more frequent vehicle maintenance because of earthquake damage to road surfaces (this will be discussed in more detail in chapters 7 and 8). After the Loma Prieta earthquake, findings point to significant economic impacts in surrounding areas such as Santa Cruz as a result of damage to road surfaces and supporting infrastructure such as bridges (Kroll et al., 1991).

The trucking industry representative interviewed expressed that the fortunes in this sector were looking up in the 18-to-24 month period leading up to the earthquakes. This was due to growth in the timber, dairy and mining industries. Preceding this period of growth, the trucking industry had been challenged by 3-to-4 years of recession. Trucking is another industry that had a skills shortage before the earthquakes. This was even more noticeable in the response phase after the 22 February 2011 earthquake as this type of skill was required to operate some of the heavy machinery used to deconstruct buildings. The sector talked of the earthquakes bringing with

them the opportunity to improve the road network design in the Canterbury region and make it more heavy vehicle friendly. For instance, one improvement identified was the re-design of some of the pre-earthquake road network in the Christchurch CBD to make it easier to deliver goods and services.

4.3 Geographic locales

4.3.1 Christchurch Central Business District (CBD)

The Christchurch Central Business District (CBD), also known as the Central City, is defined as the area bound by the four avenues: Bealey Avenue, Fitzgerald Avenue, Deans Avenue and Moorehouse Avenue. The CBD had a mix of organisations that gained from its geographical centrality as well as from having other organisations around them. Most of the major hotels in Christchurch were in or around the CBD; it had some of the tallest buildings in the region and a lot of unreinforced masonry structures vulnerable to earthquake shaking. The CBD also had some of Christchurch's major tourist attractions such as the Cathedral, which was badly damaged in the 22 February 2011 earthquake and may be deconstructed. After the 22 February 2011 earthquake, a number of other heritage buildings in the Christchurch CBD were damaged and subsequently demolished. These heritage buildings were on the national register maintained by the New Zealand Historic Places Trust (NZHPT)[21] (2012).

Among the 34 Organisation for Economic Co-operation and Development (OECD) countries, New Zealand has the fifth highest car ownership rate (New Zealand Ministry for the Environment, 2012). Furthermore, Christchurch's car ownership rate is slightly higher than the New Zealand national average, while the Christchurch CBD had one of the highest ratios of car parks to employees among the OECD countries. A lot of these car parks could not be used after the 22 February 2011 earthquake which affected the Christchurch City Council's rates and revenue sources. In addition, the Christchurch CBD had the city's main bus interchange. Consequently, the damage to and cordoning off of the CBD brought about re-routing of public and other vehicle transport to the remaining roads in greater Christchurch. As discussed earlier,

[21] A crown entity set up to preserve and conserve the culture and history of New Zealand

trucking associations mentioned the increased amount of time they spent on the road due to decreased road capacity.

At the time of the 22 February 2011 earthquake the CBD had the largest selection of retail, hospitality and entertainment establishments in the South Island (Central City Business Association, 2011). However, as detailed by the sector representative, the CBD was in decline in the time leading up to the earthquakes. It had stiff competition from the expanding suburban malls which were increasingly preferred by shoppers. It has been argued that Christchurch City had too much retail space per capita (Buchanan, 2011). However, as the hub of the South Island, retailers argued that the city served all of the South Island. The trucking and FMCG associations emphasised this as one of the pre-disaster advantages of having a presence in Christchurch.

Some studies have looked at the recovery and performance of central business districts after disaster. Chang and Falit-Baiamonte (2002) stress the importance of considering neighbourhood effects in how organisations in business districts are affected by disaster. The same neighbourhood effects also have a bearing on how the organisations recover. Olshansky (2006), in his paper on planning after Hurricane Katrina and the lessons that can be learned, talks of the successful rebuild of Kobe's CBD after the 1995 Great Hanshin earthquake.

4.3.2 **Kaiapoi Town Centre**

Kaiapoi is a historic river town which in its boom years had wool and meat processing factories. With the closure of these industries in the 1970s and 1980s respectively, Kaiapoi later became a dormitory suburb of Christchurch. Blackwell's Department Store, started in 1871 and the oldest family owned department store still operating in New Zealand, is situated in Kaiapoi (Kaiapoi Promotion Association Inc, 2012). Kaiapoi also had some heritage buildings listed with the New Zealand Historic Places Trust (NZHPT). One of these was the Kaiapoi Museum which was damaged in the 4 September 2010 earthquake and later demolished. The community in the town was very close knit.

The modern day Kaiapoi Town Centre (mainly along Williams Street) was the main retail and business area for the town and had a substantial number of unreinforced masonry (URM) buildings which were badly damaged in the 4 September 2010 earthquake. Kaiapoi had a

tremendous amount of liquefaction after the 4 September 2010 earthquake which also contributed to the damage.

4.3.3 Lyttelton Town Centre

In 2009, the New Zealand Historic Places Trust (2009) made a significant portion of Lyttelton Town one of the largest historic areas in New Zealand. This was in addition to the historic sites, such as the Lyttelton Timeball, that were already listed with the Trust. The epicentre of the 22 February 2011 earthquake was located five kilometres away from the town (GeoNet, 2011). Just as with the Christchurch CBD and Kaiapoi Town Centre, Lyttelton had a lot of URM buildings which were subsequently demolished following the 22 February 2011 earthquake. The URM buildings that were demolished were part of the history and culture of the town and this meant that the character of the town was altered.

The port town of Lyttelton has a lot of locals loyal to the town that have set up there because their roots are in Lyttelton. Lyttelton also has strong business and other associations led by a few prominent, very active people. Additionally, Lyttelton serves as an important part of the arts and crafts scene of the greater Christchurch area. This, coupled with the historic nature of the town, is a tourist draw card. Lyttelton is also home to the Port of Lyttelton and is connected to the greater Christchurch area by the Lyttelton Road Tunnel which is a conduit for most of the import and export traffic to the port. Also of importance is Evans Pass/Sumner Road used by the trucking sector to get to the port, especially important for transporting dangerous goods. The Evans Pass/Sumner road is still closed at the time of writing (July 2012). More details on the impacts of the damage to critical infrastructure in and around Lyttelton are in chapter 7.

4.4 Emergent themes from contextual interviews

This section details some of the commonalities between sectors in the response and short-term recovery phase. For most of the interviewees, aside from the ongoing earthquakes making planning difficult, the change from response to recovery was marked by the day that the Canterbury Earthquake Recovery Authority (CERA) officially took office. The continuing earthquakes made it difficult for people and for organisations to transition from response to recovery as the response clock was continually reset. With each major earthquake, buildings had

to be rechecked, staff left places of work to check on families and property and people's mindsets went back to response mode.

During the response, i.e. acute, phase after the earthquakes, some industries in the sample had an increased demand for their goods and services immediately following the earthquake. There was awareness of these requirements within the sampled industries. The goods and services required fell into three broad categories:

→ non-substitutable services;
→ equipment and goods required to support the response and search and rescue efforts (Urban Search and Rescue gear, fuel, heavy earth-moving machinery such as diggers, pre-fab housing units) and also for repair of damage to infrastructure; and
→ essential goods and services for the public (e.g. water, fuel, portable toilets, tents).

Those sectors that were needed immediately following the earthquakes had different amounts of time, after the main event, in which to provide goods and services. The trucking industry for example had a few hours to prepare as buildings in the CBD were being checked and rescue preparations made before they were called in. Sectors providing rescue gear were called on almost immediately. One organisation[22] had approximately a fortnight to prepare before needing to provide their non-substitutable services.

4.4.1 Pre-existing sectoral conditions and attributes

Interviewees were asked about other pre-existing systemic conditions that contributed to how different sectors were affected (positively or negatively) by the earthquakes. One effect was to organisations that were in or around the Christchurch CBD area; apart from the economic decline affecting these businesses, they were also subject to neighbour effects. These effects, such as benefiting from the close proximity to numerous other organisations in the same area and also the general foot traffic from the number of people who worked in or visited the CBD, were an advantage pre-disaster and became a disadvantage post-disaster. The advantage was that there was a continual flow of foot traffic in the area before the earthquakes and the disadvantage was that a large number of people, tourists and employees for instance, did not go to the CBD

[22] This service cannot be described for reasons of confidentiality

after the earthquakes. A second effect of pre-earthquake conditions was that organisations on the edge of the CBD cordon reported that post-September 2010, apart from the fall in numbers of people shopping, working and visiting the CBD, another reason for the decrease in customer numbers was that people perceived them to be closed because of their proximity to the cordon.

Furthermore, other contributing pre-earthquake conditions had to do with the industry sector of some of the affected organisations. For instance, location specific[23] businesses such as those in hospitality or retail spoke of the inability to retrieve specialised equipment or merchandise from within the Red Zone of the CBD. Both food and accommodation hospitality establishments faced difficulties relocating. This contributed to some of these organisations not being able to relocate quickly for lack of equipment or merchandise. However, the Christchurch CBD industry representative mentioned organisations that had modified the way they interacted with their customers by either starting to trade online or even door-to-door. For building suppliers, at the time of the 4 September 2010 and 22 February 2011 earthquakes the sector was still struggling to recover from the global financial crisis whereas ICT and trucking were concerned about the shortage of skilled labour.

4.4.2 **Factors that aided recovery**

On factors that aided the recovery, interviewees highlighted some organisations that had adapted to the post-disaster environment by relocating to other retail areas such as shopping malls. Interviewees were asked what would happen to the retail space used by relocated organisations when they vacated and moved back to the CBD. Almost all the respondents said this had not yet been thought about in detail but would most certainly have an effect later on in time. One respondent was of the opinion that as opposed to having the *donut effect,* with an underdeveloped CBD and well developed suburban shopping, perhaps Christchurch would need to *sacrifice* some of its shopping malls in the long run. Furthermore, some central city property owners and some of the business leaders suggested that there be a decade long moratorium on new licenses for accommodation or for the expansion of shopping malls. They explained that this would provide an opportunity to existing earthquake affected businesses to recover. Second, the moratorium

[23] The phrase "location specific businesses" is meant in two ways: the first is that clientele came because of where the organisation was located and the second is that the organisation had machinery and equipment that they could not (easily) move.

would work as a check for the sectors already over licensed prior to the 4 September 2010 earthquake. Interestingly this was in contrast to some of the messages that came from the Canterbury Earthquake Recovery Authority (CERA) on limited interference and leaving the market to sort itself.

The New Zealand Central Government made available an Earthquake Support Subsidy (ESS)[24] for organisations with 50 employees or less. The Earthquake Support Subsidy (ESS) was paid to eligible organisations in the Christchurch area that employed 50 people or less. It was originally to be paid for up to six weeks after the 22 February 2011 earthquakes but was extended to eight weeks. There was unanimity among interviewees that the ESS for businesses was especially helpful as businesses worked through insurance policies and waited for insurance payments for lost wages while also trying to plan how to move forward. Another positive step has been the collaboration between organisations post-earthquake. Interviewees noted that organisations that had different purposes or that represented opposing interests prior to the 4 September 2010 earthquake worked together afterwards towards a common goal of recovery.

Chapter 9 has a more comprehensive discussion on the aids and hindrances to recovery after the 2010 – 2011 Canterbury earthquake sequence.

4.4.3 Factors that hindered recovery

On elements that could or did hinder recovery, interviewees felt that the initial Draft Central City Plan[25], before its adoption by the Christchurch City Council (CCC), was not economically viable in the long run. Notably the proposed 7-storey height limit for buildings was seen as a disincentive for investors wanting to put their money in the Christchurch CBD as it did not offer a good enough return on investment. Also mentioned was that the recovery plan for the CBD should overall be good enough to attract new and returning investors by designing and planning for a commercially viable CBD. Interviewees said one way to do this could be by

[24] Detailed information on the Earthquake Support Subsidy can be found at http://www.msd.govt.nz/about-msd-and-our-work/newsroom/media-releases/2011/millions-for-christchurch-quake-employment-support.html.

[25] The fundamental ideas in this plan came from the CCC pre-earthquake long-term plan and from submissions by the public. Final sign-off and approval for the plan was by CERA. At the time of writing, March 2013, the plan had been reviewed and amended.

having the CBD as a mixed use residential, business and work area with multiple precincts as well as the right mix of businesses and tenants.

Without exception, all interviewees talked of the uncertainties concerning aftershocks, delayed insurance pay-outs and the consequent delay to start of rebuilding work as barriers to recovery. The general consensus was that there was not much that could be done about insurance by the various industry sectors and that it was a matter of time before this was solved. Some interviewees further expressed concern that Christchurch needed to actively market itself as still being open for business to counter the possibility of being forgotten.

4.4.4 Lessons

Interviewees were asked what lessons have been learnt after the earthquakes. One of the biggest lessons was for organisations to have business continuity and disaster recovery plans, as well as being ready to adapt and use new ways of working for example in communicating with staff and customers. Also, all the interviewees highlighted the interdependencies between the different industry sectors with each other and with the wider economy and how a problem in one sector could propagate to other sectors. This brings to the fore the need for organisations and industry sectors to be cognisant of how other organisations or sectors can affect their operations.

Importantly, all the interviewees emphasised that the primary importance for recovery is the wellbeing of people as they make up the organisation. An organisation's and a sector's recovery partly depended on the recovery of the people in it.

4.4.5 Challenges and opportunities

One of the main messages to emanate from the contextual interviews was that striking the right balance between short- and long-term recovery priorities was a challenge. This was made more difficult by the continuing earthquakes and by the lack of a clear vision for what the greater Christchurch area would recover to. Related to this was the worry many of the sectors had that if the recovery strategy and recovery activities took too long, Christchurch would be *forgotten* as the rest of New Zealand and the world moved on. Interviewees mentioned that Christchurch should not just be a gateway to the South Island but also a stopping place. However, it was acknowledged that a lot of what tourists stopped for, in the CBD at least, was damaged in the

earthquakes. Also, the extended closure of the CBD did not serve as good advertising for the City, although the pop-up mall[26] was a reminder of where the CBD used to be and what it could be again. Interestingly, in the second half of 2012, the travel site Lonely Planet[27] named Christchurch as one of the most exciting cities in New Zealand. This was attributed to the city's resilience and the emergence of new entertainment areas.

At the time of interviewing, interviewees felt that a credible vision of recovery as well as a plan to fulfill that vision were necessary to give confidence that recovery would happen.

4.4.6 Industry representation after the earthquakes

Studies (e.g. (Olshansky & Johnson, 2012; Tyhurst, 1951)) show that the formation of groups in reaction to disaster is a common phenomenon. The Canterbury earthquakes were no different. Among the myriad groups that formed were associations purporting to support one or other industry groups. These new associations were in addition to the already existing pre-earthquake industry associations. This trend was both positive and negative. Positive in that people were represented, felt empowered and could put their views across. However, in other cases this was to the detriment of the affected population or sector (e.g. Christchurch CBD) as groups claiming to represent the same organisations did not always have a unified message. Also, the associations were all vying for the attention of the same agencies involved in disaster recovery activities. This meant that the agencies had to decide who to pick and work with in recovery, which may have marginalised some groups. The associations that were the loudest were not necessarily the ones chosen. Instead, according to one recovery agency representative, the associations chosen were the ones that either had a proven track record or a viable plan for recovery (Recovery agency representative, personal communication, 2012).

Some industry sectors chose to come together and speak with one voice. This was the case in the hospitality industry where there are traditionally many associations (mostly with membership dependent on type of hospitality establishment). After the earthquakes, several hospitality associations came together to form Christchurch Hospitality Inc. (CHI). However, there are

[26] The pop-up mall was set up in October 2011 to temporarily house retail establishments as plans for the rebuild of the Christchurch CBD were still being drafted.

[27] The full Christchurch Lonely Planet review can be found at http://www.lonelyplanet.com/new-zealand/christchurch-and-canterbury/christchurch/travel-tips-and-articles/76957 (accessed March 2013)

many hospitality establishments that do not belong to any industry association. Similarly, not all the organisations in the CBD belonged to the Central City Business Association (CCBA) which was very prominent in speaking up for its membership. This might have led the authorities to think that all organisations were represented and if the unrepresented organisations wanted to be heard, they would have had to find alternative means. Regardless, the industry associations acted as representatives for their members with recovery agencies such as the Christchurch City Council (CCC) and the Canterbury Earthquake Recovery Authority (CERA).

4.4.7 Recovery goals and recovery of the Christchurch central business district (CBD)

When asked who they thought was driving the recovery, interviewees had varied responses. Some of the answers given included CERA, CCC, financiers, re-insurers and the continuing aftershocks. This list showed that Christchurch still had a way to go in articulating a common vision of recovery and how it would be achieved. A common vision is important so that all parties concerned have a common understanding of the end goal and can therefore align their organisational and sectoral goal(s) with the overall goal for recovery. This aspect is discussed in sections 8.4.3 and 9.6.1 on how uncertainty in recovery planning can be detrimental.

In addition to the recovery of their sector, interviewees were concerned about the recovery of greater Christchurch as the two were somewhat entwined. Pre-earthquakes, Canterbury, specifically greater Christchurch, was growing and for this growth to continue required external sources of funding, investment and in certain instances in-migration. This was even more important after the earthquakes. Although not explicitly stated by all interviewees, the view was that the CBD was the most visible element of the greater Christchurch rebuild, which if planned and advertised well, would serve as the flagship that would make people want to invest funds and manpower in Canterbury.

Interviewees were of the mind that it was not a matter of *if* but *when* Christchurch recovered and that it would take a concerted effort. Also dominant was the clear need to build back better than what existed before the 4 September 2010 earthquake, both for improvement as well as for financial and economic viability. Interviewees stated that there was a need to realise that the rebuild, if it was done right, presented a chance to revitalise the economy of Christchurch and

that the city's fundamental advantages had not changed following 4 September 2010. This is even as the city was different as a result of the earthquakes. For instance, one of the pre-existing conditions pointed out was that prior to the earthquakes the retail sector in the CBD in particular and the hospitality sector were performing poorly. In addition, the increasingly popular suburban malls were directly competing against the CBD for clientele. There was a chance after the earthquakes to evaluate the interaction between the CBD and suburban malls and craft an overall strategy with that in mind.

Interviewees emphasised that everyone involved in the rebuild should remember that Christchurch was not returning to where or what it was pre-4 September 2010 as the landscape had changed almost irrevocably. For instance, the pattern in the last few years before the earthquakes had been for businesses to set up or relocate in the west of the city in the Riccarton-Addington area. With the cordoning off of much of the CBD this trend accelerated. It was therefore critical for people to understand that the idea was not necessarily to *rebuild* the Christchurch CBD as was but to design and construct a *Downtown Christchurch* attractive to all users. Instead of having businesses as primary tenants, it was proposed that the Central City might be a centre for the arts, for retail and for hospitality.

In redesigning the Christchurch CBD, interviewees spoke about other opportunities for improvement. The trucking sector wish list included the possibility to enhance the road network in and around the CBD to make it more user-friendly for delivery trucks, public transport and other road users. Further opportunities came from the ICT and building suppliers sectors to trial and implement new technologies creating a hi-tech Christchurch. The ICT sector mentioned the possibility for use of smart technologies for whoever would occupy the Central City whereas for the construction (building suppliers) sector the use of building techniques to minimise damage and disruption could be incorporated. There is more discussion on the recovery of the CBD in chapter 7.

4.5 Chapter summary

This chapter presented the results from the contextual interviews with business and industry leaders. Also presented was contextual information on the sectors included in the study, complemented with findings from past research into organisational disaster recovery. The information from this section will be used with data from the other results chapters, 5 and 6, in

later parts of the thesis for an analysis of the key elements of organisational and sectoral recovery.

From the contextual interviews, respondents detailed the economic and geographic advantages of being in Christchurch: its geographic location allowing for easy access to land and sea ports as well as the ease of reaching the South Island market. Another advantage is Christchurch's attractiveness to potential and current employees. No industry sector reported having faced a disaster of such magnitude in their history in New Zealand.

Findings from the contextual interview data point to sectors being affected in varying ways after the earthquakes. For instance, some sectors such as trucking had increased demand for their services while building suppliers were affected conversely. Some of the effects were a result of pre-earthquake characteristics such as type of goods and services delivered or organisational location. Furthermore, some of the interdependencies between different industry sectors as well as with the wider economy highlighted how a problem in one sector could propagate to other sectors.

Other lessons brought up are the importance of staff in recovery and the role of business continuity plans after disaster. Some of the major post-earthquake challenges identified included making the transition from response to recovery as well as the shortage of skills for sectors such as hospitality and trucking. However, respondents narrated that there were also opportunities post-disaster such as the chance to incorporate long planned for and needed improvements while crafting recovery strategies.

Interviewees reported that factors that aided recovery included the willingness and ability of organisations to adapt as well as assistance from Central Government in the form of the earthquake support subsidy (ESS). Interviewees detailed that they thought the financial non-viability of the Central City recovery plan was a hindrance to recovery. Similarly, the uncertainty on the duration of earthquake activity was also seen as a hindrance to recovery.

Furthermore, interviewees spoke of what they viewed as lack of clear leadership, in leading the recovery effort, as not helpful. It should be noted that this was at the start of the short-term recovery phase.

Specific to the geographic locales, an emergent theme was the existence of unreinforced masonry (URM) buildings making them more vulnerable to earthquakes. In addition, the extent of damage to individual buildings, in the CBD or town centres, also had an effect on neighbouring buildings.

Interestingly, some of the aspects identified from the contextual interviews with business and industry representatives were the same as those identified in the case study interviews with organisations in the study. Results from the case study interviews are presented in chapter 6.

The next chapter has findings from the surveys, deployed to collect mainly quantitative information for the study.

5 Surveys

In this study, the surveys were used to capture mainly quantitative data. Their advantage lay in the possibility to collect information from multiple respondents using standardised questions and in the same timeframe. As outlined in chapter 3, all three surveys deployed contained two main components: 1) questions on impacts of the earthquakes to organisations and industry sectors as well as what measures they undertook to recover, and 2) questions asking about organisational resilience. The survey questionnaires are in appendices K to M. For each of the surveys, not all the survey results are presented here. This is both for reasons of space and to present results that will best explain the effects of the earthquakes. Extra results tables are included in appendices C to E.

In this chapter, the survey results are presented in the order in which the surveys were deployed. For some of the larger tables, some of the values have been highlighted to make it easier for the reader. There is also some brief discussion of the survey results throughout the chapter. The results from all surveys are then summarised in section 5.4 in a discussion on sectoral challenges and temporal trends across sectors. Crucially, the aspects that emerge in this chapter are used in analysis to come up with sectoral signifiers of recovery (chapter 7), system behaviour that influences recovery (chapter 8), aids, hindrances and points of intervention in recovery (chapter 9) and organisational disaster resilience (chapter 10).

The surveys were sent to the same organisations for the duration of the study, however as shown in Tables 5-1 and 5-2, the number of survey responses decreased but the response rates increased with subsequent surveys. At each survey point, organisations were asked if they wished to take part in future research. Some of the respondents declined and for ethical reasons were not contacted again. It should also be noted that some of the organisations in this study fall within an industry sector group and might also physically be in one of the geographic sectors sampled (e.g. hospitality organisations located in the Christchurch CBD). In such cases, data were analysed based only on the sector (industry or geographic) they were selected for in this study. Tables 5-1 and 5-2 show when each survey was deployed and what the survey response rates were. The entire sample group totals in Tables 5-1 and 5-2 are not the same because Table 5-2 shows the complete survey responses that were used in the analysis.

Table 5-1: Survey deployment timeline and response rates

Survey deployment timeline and response rates					
	Survey Launch Date	**Survey Closing Date**	**Number of organisations**	**Returned responses**	**Response rate (%)**
Survey 1[28]	17 November 2010	18 February 2011	879	379	43%
Survey 2[29]	31 May 2011	18 September 2011	309	176	57%
Survey 3	12 March 2012	19 May 2012	98	70	71%

Table 5-2: Sectoral response rates for Surveys 1, 2 and 3

	N		
	Survey 1	**Survey 2**	**Survey 3**
Building Suppliers	30	11	7
Critical Infrastructure	24	16	7
FMCG	42	16	5
Hospitality	32	7	2
ICT	55	27	13
Trucking	38	15	6
Christchurch CBD	33	17	5
Kaiapoi Town Centre	40	17	8
Lyttelton Town Centre	Did not participate	39	10
Entire Sample Group	294	165	63

As can be deduced from the earthquake timeline shown in chapter 3, this study was originally intended to track recovery for organisations after *one* major event: that of 4 September 2010. However, after 22 February 2011, the study became one of organisational recovery after multiple events. Because of this, results for each survey are presented on their own and discussed. Lastly, a limitation of the research is that there are no data from possible permanently closed

[28] In Surveys 1 and 2, organisations were asked if they would like to participate in further research. Some organisations declined, hence the difference in numbers between returned responses in one survey and deployed surveys in the next. Additionally, there was a moratorium on research in the months following the 22 February 2011 earthquake which led to a later than planned deployment date for Survey 2.

[29] Lyttelton organisations were included after the 22 February 2011 earthquake and took part in Surveys 2 and 3 only.

organisations that were on the original starting sample list. The knowledge of why these organisations closed permanently would be helpful to disaster researchers and policymakers. It appears though that not many organisations closed permanently after the 22 February earthquake. Data analysed by Statistics New Zealand (2012e) showed no significant (2.5%) business closure in Christchurch between February 2011 and February 2012.

5.1 Survey 1 (deployed 17 November 2010 to 18 February 2011)

Survey 1 was intended to capture the immediate impacts to organisations in the greater Christchurch area in the aftermath of the 4 September 2010 earthquake. In the first part of the survey, organisations were asked if they had been *affected* by the 4 September 2010 earthquake. The definition of affected was left to the respondents. It appears that most respondents probably thought of it in the negative as the answers given to subsequent questions showed that the consequences for their organisations were not favourable. Organisations that reported not being affected were directed to the second part of the questionnaire which contained statements on organisational resilience. Therefore, the organisational impact data for Survey 1 presented in this section are for organisations that reported being affected.

The majority (80%) of organisations were affected by the events of 4 September 2010. Results for affected organisations and for those that closed for a period of time after the earthquake are shown in Table 5-3. Overall, only 1% of the total sample reported closing permanently. The sectors with the highest percentage of organisations reporting (temporary) closure were Christchurch CBD (97%), hospitality (93%) and Kaiapoi (87%). For Christchurch CBD, this is attributable to the official cordon that was placed around the CBD after the 4 September 2010 earthquake. As well, most of the hospitality organisations were located in or around the CBD and were thus similarly affected. Some organisations reported closing because of damage to premises close to or next to theirs. In Kaiapoi, the large number of organisations closing was due to the extensive liquefaction and building damage that the town experienced after the 4 September 2010 earthquake. After the 4 September 2010 earthquake, the sectors reporting the highest average number of closure days were Kaiapoi and trucking with an average of 12 days each, followed by Christchurch CBD with an average of 8 days.

*Table 5-3: Affected organisations after the 4 September 2010 earthquake including organisations that reported closure**

Affected organisations after the 4 September 2010 earthquake including organisations that reported closure				
	Affected	**Not Affected*** **	**Affected organisations that temporarily or permanently closed**	**Affected organisations that did not close**
Building Suppliers**	70%	27%	45%	55%
Critical Infrastructure	92%	8%	41%	59%
FMCG	88%	12%	76%	24%
Hospitality	94%	6%	93%	7%
ICT	56%	44%	57%	43%
Trucking	71%	29%	29%	71%
Christchurch CBD	91%	9%	97%	3%
Kaiapoi Town Centre	90%	10%	87%	13%
Entire Survey 1 Sample	80%	20%	69%	31%

**Owing to rounding, for this and subsequent tables some of the figures might add up to just under or just over 100%*
*** Not all organisations answered this question; totals may not add up to 100%*
**** Figures for not affected organisations are included for completion*

After a disaster, it has been documented that organisations can experience a change in revenue for various reasons including supply chain problems, lack of customers or even their goods and services not being required after disaster (Rose & Lim, 2002). Organisations in this study were asked to provide information on changes to revenue, suppliers and customers in the aftermath of the 4 September 2010 earthquake. These results are presented in Tables 5-4 and 5-5.

*Table 5-4: Organisational revenue change and use of new suppliers after the 4 September 2010 earthquake**

Organisational revenue change and use of new suppliers after the 4 September 2010 earthquake					
	Change in revenue			Need to use new suppliers	
	Revenue has decreased	No change	Revenue has increased	No	Yes
Building Suppliers	59%	23%	14%	95%	5%
Critical Infrastructure	18%	50%	23%	82%	18%
FMCG	16%	62%	16%	68%	32%
Hospitality	67%	15%	19%	85%	11%
ICT	20%	70%	10%	93%	7%
Trucking	38%	46%	17%	96%	4%
Christchurch CBD	77%	19%	3%	94%	3%
Kaiapoi Town Centre	64%	28%	8%	90%	10%
Entire Survey 1 Sample	45%	39%	13%	87%	12%

**Owing to rounding, for this and subsequent tables some of the figures may add up to just under or just over 100%*

The general trend for changes in revenue was down. Christchurch CBD (77%), hospitality (67%) and Kaiapoi (64%) had more organisations reporting negative revenue changes. Building suppliers also showed a marked decrease in revenue with 59% of organisations reporting this. In the opposite direction, and not always obvious after disaster, some sectors reported an increase in revenue. Critical infrastructure had the most organisations (23%) reporting an increase while hospitality, trucking and FMCG had 19%, 17% and 16% respectively. Critical infrastructure organisations, such as those dealing with waste, detailed that the increase in revenue was due to the increased demand for their services after the 4 September 2010 earthquake. The sector with the most organisations showing no change in revenue in the period after the earthquake was ICT (70%) followed by FMCG (62%) and critical infrastructure at 50% of organisations.

Most organisations stated that they did not need to use new suppliers after the 4 September 2010 earthquake. FMCG had the most organisations (32%) reporting the use of new suppliers while only 18% of critical infrastructure organisations reported the same. For FMCG this had to do with replacement of larger than usual quantities of product in as short a time as possible after clean up and reopening of premises, as well as the decision to stock more of certain products

needed by the public. These products included water, tinned foods, chocolate and diapers. For critical infrastructure, the need to use new suppliers was for similar reasons to FMCG. They needed to replace and repair more equipment than was usual as they made time critical repairs to earthquake damaged infrastructure.

When asked about changes to their customer base, organisations reported mixed results (Table 5-5). For more than half the sectors, the pattern showed that a large percentage of organisations experienced no change in customer base. Sectors that did report a substantial decrease in their customer base include Christchurch CBD (47%) as well as building suppliers and Kaiapoi, both at 29%. The Christchurch CBD experienced this for two main reasons; first was that the organisations were in a cordoned off area in the first few days after the 4 September 2010 earthquake and second was the public's perception that organisations in and around the CBD were still closed even after they had started trading again. The loss of customers for building suppliers was a continuing pre-earthquake trend attributable to the sector suffering a downturn prior to the earthquakes and also the cancellation of work booked prior to the earthquake (e.g. kitchen renovations booked pre-earthquake may not be needed as a result of earthquake damage). Kaiapoi attributed the decrease in customers to their being closed for a longer period of time due to damage caused by the 4 September 2010 earthquake.

*Table 5-5: Change in customer base after the 4 September 2010 earthquake**

Change in customer base after the 4 September 2010 earthquake					
	Decreased substantially	**Decreased moderately**	**No change**	**Increased moderately**	**Increased substantially**
Building Suppliers	29%	5%	57%	5%	5%
Critical Infrastructure	0%	9%	64%	9%	14%
FMCG	0%	20%	66%	9%	3%
Hospitality	19%	41%	26%	7%	4%
ICT	0%	10%	77%	7%	3%
Trucking	4%	17%	58%	21%	0%
Christchurch CBD	47%	33%	7%	10%	0%
Kaiapoi Town Centre	29%	23%	34%	9%	3%
Entire Survey 1 Sample	16%	20%	47%	9%	4%

**Owing to rounding, for this and subsequent tables some of the figures might add up to just under or just over 100%*

Kunreuther (2006) writes that insurance is one of the ways that the effects of disaster can be mitigated. This is of course contingent on the organisation having insurance in the first place and the insurance being adequate to cover losses after significant events. Organisations were presented with a list of insurance types and asked to state which ones their organisations possessed. The results are in Table 5-6.

*Table 5-6: Type of insurance**

	Type of insurance						
	Cash flow, income protection, organisation interruption	**Property and Buildings**	**Organisation assets and equipment**	**Motor Vehicles**	**Public Liability**	**Commodities and Goods**	**Other**
Building Suppliers	62%	62%	81%	81%	90%	71%	14%
Critical Infrastructure	41%	59%	55%	59%	73%	36%	45%
FMCG	71%	66%	71%	74%	71%	66%	26%
Hospitality	85%	48%	81%	44%	74%	74%	0%
ICT	40%	50%	90%	53%	77%	37%	27%
Trucking	50%	63%	71%	67%	71%	33%	25%
Christchurch CBD	77%	53%	80%	60%	70%	77%	13%
Kaiapoi Town Centre	51%	46%	74%	43%	77%	40%	14%
Entire Survey 1 Sample	60%	55%	76%	59%	75%	54%	20%

**Owing to rounding, for this and subsequent tables some of the figures might add up to just under or just over 100%*

Organisation assets and equipment and *public liability* were the most common types of insurance across all the sectors. The breakdown for the other types of insurance shows differences between sectors. For instance building suppliers and FMCG have the highest incidences of *motor vehicle* insurance. This is a result of their owning the vehicles that they use, for example to deliver product in their day-to-day operations. Additionally, a lot of the critical infrastructure providers (45%) reported having *other* types of insurance. For those that gave a description, in all cases this was self-insurance. In a report on liability and insurance for critical infrastructure providers, Coopers and Lybrand (1997) found that self-insurance was common in this sector partly because the deductibles with traditional insurance are large.

Related to insurance is the ability of organisations to finance possible increased or unforeseen costs after a major event and is one of the ways organisations can recover (Alesch & Holly,

2002). Finance is required to maintain cash flow, to purchase new equipment or services and to keep paying employees. Complete results for the means organisations elected to use to finance their recovery are in Table 5-7.

The most common type of finance option was organisational cash flow followed by insurance claim. Christchurch CBD and Kaiapoi had the most organisations with savings as one of the means of financing their recovery. The Christchurch CBD (37%), hospitality (30%) and Kaiapoi (20%) were more likely to use the Earthquake Support Subsidy (ESS) given by the Central Government to organisations with 50 or less employees. Organisations that used the ESS not only had knowledge of the existence of the subsidy, they also made an effort to apply for it. In the literature, not all organisations affected by disaster get to know about the assistance available and of those that do know not all of them access it (Barksdale, 1998). Organisations that received the ESS state that it helped them to not make rash business decisions after the earthquake such as laying employees off as a means of saving money.

*Table 5-7: Organisational recovery finance options after 4 September 2010**

Organisational recovery finance options after 4 September 2010								
	Organisational cash flow	**Savings**	**Money borrowed from family or friends**	**Bank Loan**	**Credit Cards**	**Insurance claim**	**Earthquake Wage Subsidy[30]**	**Other**
Building Suppliers	86%	19%	10%	24%	14%	14%	10%	10%
Critical Infrastructure	77%	9%	0%	5%	0%	18%	0%	14%
FMCG	46%	20%	0%	0%	0%	37%	3%	11%
Hospitality	63%	22%	11%	22%	11%	63%	30%	4%
ICT	73%	7%	3%	7%	3%	10%	17%	10%
Trucking	58%	4%	0%	4%	0%	25%	13%	17%
Christchurch CBD	57%	33%	10%	23%	13%	43%	37%	10%
Kaiapoi Town Centre	51%	34%	9%	20%	6%	43%	20%	17%
Entire Survey 1 Sample	62%	20%	5%	13%	6%	33%	16%	12%

** Figures may add up to more than 100% as some organisations may use multiple alternatives of recovery finance*

Another possible post-disaster effect to organisations is the employee hire and redundancy rate (Kondrasuk, 2004). This can be used to check the health of the organisation. Organisations not doing well could be laying people off or could have employees leaving as a result of the earthquakes. Results are shown in Table 5-8. Most organisations reported that the movement of employees was not a result of the earthquake but a normal part of their business cycle. The larger part of the sample reported not making any employees redundant. In fact critical infrastructure (45%), trucking (33%), FMCG (31%) and hospitality (30%) sectors took on more staff. The sectors reported that this was because of the increased workload related to repair, remediation and clean-up caused by the earthquake. It should be noted again, that Survey 1 results are from the first few months after the first earthquake and before the February earthquake.

[30] This is also known as the Earthquake Support Subsidy (ESS)

*Table 5-8: Staff redundancy and hire after 4 September 2010 earthquake**

Staff redundancy and hire after 4 September 2010 earthquake				
	Staff redundancy		Staff hire	
	No	Yes	No	Yes
Building Suppliers	95%	5%	81%	19%
Critical Infrastructure	100%	0%	55%	45%
FMCG	100%	0%	69%	31%
Hospitality	85%	11%	70%	30%
ICT	93%	7%	73%	27%
Trucking	92%	8%	67%	33%
Christchurch CBD	90%	10%	73%	23%
Kaiapoi Town Centre	91%	6%	89%	11%
Entire Survey 1 Sample	92%	6%	72%	27%

**Owing to rounding, for this and subsequent tables some of the figures might add up to just under or just over 100%*

Organisations were presented with alternatives for how they were affected after the 4 September 2010 earthquake. They were asked to rank, using a 4-point Likert scale from *not at all* to *very,* how severely they were affected by each alternative. Each organisation's degree of effect ODoE was calculated, see equation 5-1.

$$\text{Organisational Degree of Effect } (ODoE) = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{Si}{3}\right) * 100$$

Equation 5-1: Computation for organisational degree of effect for factors causing disruption to organisations operations after the earthquake

i is the disruptive factor, s is the score assigned a value from 0 (not at all) to 3 (very) for each disruptive factor and n is the total number of disruptive factors. For example, each organisation assigns a score (from 0 to 3) for each disruptive factor. The organisational individual disruptive factor scores are totalled, averaged and then divided by 3 (the maximum possible score for each disruptive factor). This is then multiplied by 100 to give a score out of 100. To determine how each sector was affected, a sectoral DoE score is calculated by averaging the individual ODoE

scores. The higher the score the more severely that sector was affected by the given alternative. The results from this computation are in Table 5-9. The three highest degrees of effect for each sector are in bold highlighted cells.

Most of the sectors were not affected by injury to employees. This is because of the timing of the 4 September 2010 earthquake which occurred in the early hours on a Saturday morning when not many people were at work. More sectors were affected by the disruption to electricity than by any other factors. This shows how dependent industry is on the use of electricity to run their operations (Rose et al., 1997). Across the entire sample, the highest degrees of effect (DoE) were for electricity disruption (38/100), damage to or closure of nearby buildings (37/100) and damage to or closure of adjacent organisations or buildings (35/100). An inspection of the responses shows that both Christchurch CBD and Kaiapoi were heavily affected by damage to or closure of adjacent organisations or buildings and damage to or closure of nearby buildings**.** This exemplifies the neighbourhood effects that organisations in CBDs and town centres face even as they benefit from having organisations in close proximity whose foot traffic also adds to their business. Additionally, the Christchurch CBD (DoE 69/100) was affected by their inability to access their premises. This is again because of the CBD cordon as well as being in close proximity to buildings that were declared unsafe and fenced off. Kaiapoi on the other hand was affected by water supply disruption (DoE 75/100) as a result of damage to water and waste water systems caused by the ground shaking and subsequent liquefaction (Tonkin & Taylor, 2011). FMCG organisations report being affected by non-structural damage and damage to inventory which was caused by the shaking as well as the collapse of shelving.

For most disasters, a lot of emphasis is placed on physical damage of the organisation's premises. The results in Table 5-9 show that there are other contributors to business disruption after an earthquake or other disaster apart from physical damage. For instance, after the 4 September 2010 earthquake, non-physical damage factors such as electricity supply disruption or inability to access premises were reported to be more disruptive than physical damage to the organisation's premises.

*Table 5-9: Sectoral degree of effect (for organisations that reported being affected) after the 4 September 2010 earthquake**

Sectoral degree of effect after the 4 September 2010 earthquake															
	Structural damage to buildings	**Non-structural damage**	**Damage to equipment**	**Damage to computers**	**Damage to inventory or stock**	**Water supply disruption**	**Sewerage or effluent disruption**	**Communications disruption**	**Damage to ground surface**	**Damage to or closure of adjacent organisations or buildings**	**Damage to or closure of nearby buildings**	**Unable to access site**	**Injury to employees**	**Electricity disruption**	**Other**
Building Suppliers	**25**	22	11	8	**35**	10	3	14	10	13	13	6	0	**24**	11
Critical Infrastructure	23	**29**	**24**	15	15	**24**	18	18	18	22	15	11	0	**33**	11
FMCG	22	**43**	27	10	**71**	30	19	31	10	18	31	9	4	**41**	13
Hospitality	14	21	19	5	46	36	17	18	3	**53**	**53**	**55**	0	47	4
ICT	17	30	18	13	15	25	12	**42**	11	30	32	**38**	0	**40**	14
Trucking	15	14	14	4	**26**	13	8	**22**	11	4	7	4	0	**22**	8
Christchurch CBD	31	30	15	9	16	16	8	33	6	**62**	**64**	**69**	0	34	17
Kaiapoi Town Centre	44	28	25	12	37	**75**	68	52	52	**77**	**80**	62	3	62	20
Entire Survey 1 Sample	24	27	19	10	33	28	19	29	15	**35**	**37**	32	1	**38**	12

** The three highest degrees of effect for each sector are in **bold highlighted cells**. All scores are out of a possible total of 100*

Organisations were also asked what factors helped mitigate the effects of the earthquake. These are shown in Table 5-10. The score for each sector was arrived at using the same method as for factors of disruption. Again, the higher the value, the more that option contributed to mitigating

the effects of the earthquake. The three highest mitigation factors, for each sector, are shown in bold highlighted cells.

*Table 5-10: Sectoral mitigation factor effect (for organisations that reported using these measures) after 4 September 2010**

Mitigation factor effect after 4 September 2010 (scores out of a possible maximum of 100)																
	Back-up/alternatives to utilities	**Utilities restored quickly**	**Relationship with supplier**	**Relationship with staff**	**Relationship banks/lenders**	**Relationship with neighbours**	**Available cash or credit**	**Spare resources**	**Insurance**	**Business continuity, emergency management**	**Back-up site**	**Practiced**	**Emergency kit**	**Building design**	**Relationship with advisor/mentor**	**Other**
Building Suppliers	22	**47**	43	**63**	30	18	33	15	30	20	10	18	18	**77**	18	0
Critical Infrastructure	55	76	59	**85**	11	23	38	64	32	**83**	32	79	53	**83**	20	**100**
FMCG	25	**61**	**61**	**81**	30	26	41	48	51	58	27	49	31	**73**	30	40
Hospitality	17	**62**	43	81	49	48	**64**	28	57	22	7	4	6	**86**	10	50
ICT	24	**65**	30	**68**	21	25	44	19	13	39	27	33	17	**73**	12	33
Trucking	13	**49**	20	**61**	28	20	28	32	33	26	10	21	23	**70**	20	33
Christchurch CBD	19	49	49	**65**	31	45	47	23	36	37	27	24	21	**71**	18	**67**
Kaiapoi Town Centre	44	**52**	48	**71**	46	51	61	40	48	36	37	24	18	**56**	29	0
Entire Survey 1 Sample	27	**58**	44	**72**	31	32	44	34	37	40	22	32	23	**73**	20	40

** The three highest factors of mitigation for each sector are in **bold highlighted cells.** All scores are out of a possible maximum of 100*

As shown in Table 5-10, well-designed and well-built buildings (73/100) and relationship with staff (72/100) were the two mitigation factors that were common across all sectors. This shows the importance of staff to an organisation's recovery and of pre-disaster activities such as

reinforcing buildings. In comparison to the other sectors in the study, organisations from the critical infrastructure sector found the existence of business continuity or emergency plans and the practicing of these plans as being helpful in lessening the effects of the earthquake. For FMCG organisations that carry a lot of stock and rely on timely delivery, relationship with supplier proved crucial. For ICT and trucking, the non-disruption or quick restoration of services (e.g. electricity and roads) was of benefit. After the 4 September 2010 earthquake, the restoration times for electricity was exemplary (Eidinger, Tang, & O'Rourke, 2010). However, for organisations from the Christchurch CDB and hospitality samples, quick restoration times may not have featured prominently because by the time organisations were let into their premises, services had been restored.

5.2 Survey 2 (deployed 31 May 2011 to 18 September 2011)

The original aim of Survey 2 was to gather information on ongoing recovery efforts from affected organisations and industry sectors after the 4 September 2010 earthquake. Although Survey 2 was used for this purpose, it was also used to gather information on impacts to organisations after the 22 February 2011 Christchurch earthquake. This earthquake's epicentre was located near the town of Lyttelton and close to the built up area of the Christchurch CBD. It occurred at 12:51pm on a weekday. Organisations from the port town of Lyttelton were included in the study at this point as the town centre was badly damaged by the earthquake. Consequently, some of the questions in Survey 2 asked for information on both the 4 September 2010 and 22 February 2011 events.

The results for how the different sectors were affected after the 22 February 2011 earthquake are presented in Table 5-11. It is clear that the nature and location of the 22 February 2011 earthquake, close to a built up area and at shallow depth, resulted in more severe impacts to organisations than the 4 September 2010 earthquake. Almost all organisations taking part in Survey 2 reported being affected by the 22 February 2011 earthquake.

*Table 5-11: Per cent of organisations reporting being affected or not affected**

Per cent of organisations reporting being affected or not affected				
	4 September 2010		22 February 2011	
	Affected	Not Affected	Affected	Not Affected
Building Suppliers	82%	18%	100%	0%
Critical Infrastructure	94%	6%	100%	0%
FMCG**	93%	0%	100%	0%
Hospitality	100%	0%	86%	14%
ICT	63%	38%	96%	4%
Trucking	100%	0%	100%	0%
Christchurch CBD	93%	7%	100%	0%
Kaiapoi Town Centre**	100%	0%	86%	7%
Lyttelton Town Centre**	77%	20%	100%	0%
Entire Survey 2 Sample	83%	16%	94%	6%

**Owing to rounding, for this and subsequent tables, numbers might just under or just over 100%*
***Not all organisations answered this question therefore numbers do not add up to 100%*

In the disaster literature, findings point to organisations adapting as one of the elements that may help recovery (H. E. Aldrich & Pfeffer, 1976; Faulkner, 2003). For Survey 2, in addition to being asked how long they may have closed after the 4 September 2010 and 22 February 2011 earthquakes, organisations were also asked their operational hours (see Table 5-12). The ability to adjust to a possible change in clientele or in organisational working hours is one way of adapting to a post-disaster environment and in some cases may lead to saving of resources. In other cases, such as for some organisations in ICT, this meant that the organisation was able to deliver more in-demand goods and services or to catch up on lost production.

Hospitality had the most organisations closing permanently after both the 4 September 2010 and 22 February 2011 earthquakes at 14% and 43% respectively. After February, there was also an increased number of organisations closing from the Christchurch CBD (47%). Critical infrastructure and trucking were the sectors operating for longer hours after both earthquakes.

This is because of the increased demand for their services. Some organisations (e.g. from the Christchurch CBD) interpreted closing permanently as moving to and re-opening in a location other than the area they were in at the time of the earthquake. However, from analysis of the data, this interpretation was from very few organisations in the sample. Some organisations talked of moving to other towns in New Zealand such as Nelson and Timaru.

*Table 5-12: Closure period following 4 September 2010 and 22 February 2011 earthquakes**

Closure period following 4 September 2010 and 22 February 2011 earthquakes										
	4 September 2010					22 February 2011				
	Closed temporarily	Closed permanently	Open usual hours	Open fewer hours	Open longer hours	Closed temporarily	Closed permanently	Open usual hours	Open fewer hours	Open longer hours
Building Suppliers	55%	0%	36%	9%	0%	64%	9%	18%	9%	0%
Critical Infrastructure	50%	0%	19%	13%	19%	50%	0%	13%	13%	25%
FMCG	64%	0%	21%	7%	0%	50%	14%	21%	0%	7%
Hospitality	71%	14%	14%	0%	0%	29%	43%	29%	0%	0%
ICT	46%	0%	33%	8%	4%	63%	0%	29%	4%	4%
Trucking	33%	0%	25%	17%	25%	17%	0%	42%	8%	33%
Christchurch CBD	87%	7%	0%	0%	0%	47%	47%	0%	0%	0%
Kaiapoi Town Centre	79%	7%	7%	7%	0%	57%	0%	21%	14%	0%
Lyttelton Town Centre	57%	3%	29%	11%	0%	66%	9%	11%	3%	9%
Entire Survey 2 Sample	60%	3%	23%	9%	5%	55%	11%	19%	6%	9%

**Owing to rounding, for this and subsequent tables, numbers might just under or just over 100%*

Some organisations from Kaiapoi and Lyttelton Town Centres linked the number of hours (more or fewer) they operated to their change in revenue following the earthquakes. Other organisations pointed to an increase or decrease in customers or in workload as the reason for changes in revenue. Organisations were given two consecutive time periods: from 4 September 2010 to 22 February 2011 and after 22 February 2011 in which to detail any changes to their revenue. Revenue change results are in Table 5-13. For both time periods, the overall trend in

revenue change was down. This is with the exception of the ICT, FMCG and critical infrastructure sectors which experienced mainly no change in revenue. Organisations were not asked to state if the changes in revenue were in comparison to the same period in the previous financial year. From interviews with different organisations in the study, it appears that respondents used their existing business practices and calculated their revenue changes based on what they expected to receive for that time of the year. Future surveys asking for this information would do well to specify a comparative period as a baseline for organisations to use in calculating revenue change.

*Table 5-13: Percentage of organisations in each sector and reported revenue changes**

Percentage of organisations in each sector and reported revenue changes						
	Organisation reporting revenue decrease		Organisations reporting no change to revenue		Organisation reporting revenue increase	
	Between 4 September 2010 and 22 February	After 22 February 2011	Between 4 September 2010 and 22 February	After 22 February 2011	Between 4 September 2010 and 22 February	After 22 February 2011
Building Suppliers	73%	82%	18%	0%	9%	18%
Critical Infrastructure	13%	38%	50%	25%	19%	19%
FMCG	21%	29%	50%	29%	29%	43%
Hospitality	71%	86%	14%	0%	29%	29%
ICT	17%	13%	67%	54%	17%	33%
Trucking	42%	42%	25%	25%	33%	33%
Christchurch CBD	60%	87%	27%	0%	20%	20%
Kaiapoi Town Centre	36%	14%	21%	36%	21%	21%
Lyttelton Town Centre	40%	60%	40%	20%	11%	11%
Entire Survey 2 Sample	37%	47%	39%	24%	19%	24%

**Owing to rounding, for this and subsequent tables, numbers might just under or just over 100%*

Organisations were then asked how they would finance their recovery. Results are in Table 5-14. As in Survey 1 (Table 5-7), organisations reported using a combination of financing options in Survey 2. Just as after the 4 September 2010 earthquake, the most frequently reported means of

recovery was organisational cash flow. More organisations from the Christchurch CBD used the Earthquake Support Subsidy (ESS) made available by Central Government and targeted at organisations with less the 50 employees. The ESS was made available after both the 4 September 2010 and 22 February 2011 earthquakes.

*Table 5-14: Per cent of organisations in each sector and means of recovery finance**

Per cent of organisations in each sector and means of recovery finance								
	Organisation cash flow	**Savings**	**Money borrowed from family or friends**	**Bank loan**	**Credit cards**	**Insurance claim**	**Earthquake Wage Subsidy (ESS)**	**Other**
Building Suppliers	91%	27%	18%	27%	9%	27%	36%	0%
Critical Infrastructure	81%	6%	0%	6%	0%	44%	6%	0%
FMCG	86%	36%	0%	14%	0%	43%	7%	7%
Hospitality	29%	29%	43%	29%	14%	86%	29%	14%
ICT	67%	13%	4%	17%	0%	25%	21%	8%
Trucking	83%	17%	0%	8%	0%	25%	25%	8%
Christchurch CBD	67%	33%	13%	27%	13%	67%	60%	0%
Kaiapoi	79%	36%	0%	7%	0%	21%	29%	0%
Lyttelton	43%	40%	3%	17%	0%	37%	31%	31%
Entire Survey 2 Sample	67%	27%	6%	16%	3%	39%	27%	11%

**Owing to rounding, for this and subsequent tables, numbers might add up to just under or just over 100%*

For staff redundancy and hire, shown in Table 5-15, critical infrastructure and trucking were the only sectors to not lay staff off (see Table 5-8 for staff redundancy and hire after Survey 1). In a reflection of the surge in demand for their services post-earthquake, trucking (67%) and critical infrastructure (56%) were the two sectors that had the most hires. Just over half the building supplier organisations and half of FMCG reported taking on new staff. In the FMCG sector, aside from an increased demand for goods, an increase in staff was necessitated by the massive clean-up resulting from breakage and damage to stock. For the Christchurch CBD and

hospitality sectors, certain organisations reported that some of their employees were let go in order to look for jobs elsewhere due to the extended closure period and the uncertainty around re-opening.

*Table 5-15: Staff redundancy and hire after 22 February 2011**

Staff redundancy and hire after 22 February 2011				
	Staff redundancy		Staff hire	
	No	Yes	No	Yes
Building Suppliers	82%	18%	45%	55%
Critical Infrastructure	100%	0%	44%	56%
FMCG	93%	7%	43%	50%
Hospitality	43%	57%	86%	14%
ICT	88%	8%	63%	33%
Trucking	100%	0%	33%	67%
Christchurch CBD	47%	47%	73%	20%
Kaiapoi	79%	14%	71%	21%
Lyttelton	71%	26%	66%	29%
Entire Survey 2 Sample	81%	19%	61%	39%

**Owing to rounding, for this and subsequent tables, numbers might add up to just under or just over 100%*

Organisations were asked the major reasons for the closure of the organisation (Table 5-16). The three most cited reasons for closure, per sector, are in bold highlighted cells. More organisations outlined the need to clear up damage to the interior as the major reason for closure. All of the organisations in the Christchurch CBD and most (71%) of the hospitality organisations reported building located within cordoned-off area[31] as one of the reasons for closure. For the critical infrastructure sector, there was no one main reason for closure. This might be an artefact of the organisations having assets and infrastructure across town and being able to work from many

[31] The Christchurch CBD was cordoned off for an extended period after the 22 February 2011 earthquake in some cases for as long as a year. More detail about the progressive access can be found at www.cera.govt.nz.

places as they repaired and remediated. The number of closure reasons given by each organisation will be used to calculate the closure impact factor used in chapter 7.

Table 5-16: Closure factors after 22 February 2012 earthquake – per cent of organisations by sector***

Closure factors after 22 February 2012 earthquake – per cent of organisations by sector															
	Building waiting to be structurally assessed	**Building declared unsafe**	**Building waiting to be repaired**	**Building located within cordoned-off area**	**Needed to clear up damage to interior**	**Needed to clear up damage to exterior**	**Machinery loss or damage**	**Stock loss or damage**	**Office equipment loss or damage (including computer)**	**Damage to immediate locality (e.g. neighbouring buildings or pavements, prevented access)**	**Could not obtain replacement supplies or materials**	**Could not deliver supplies/services to customers**	**Employees unable to get to work**	**Owner or manager had family or other commitments that prevented reopening**	**Other**
Building Suppliers	**45%**	0%	9%	18%	**36%**	18%	18%	27%	27%	9%	18%	**45%**	18%	9%	0%
Critical Infrastructure	6%	13%	13%	13%	**19%**	**19%**	6%	6%	**19%**	**19%**	0%	**19%**	**19%**	6%	13%
FMCG	21%	21%	**36%**	21%	**50%**	36%	14%	**43%**	14%	14%	0%	21%	14%	7%	14%
Hospitality	57%	43%	57%	**71%**	**71%**	43%	43%	**71%**	43%	43%	29%	29%	43%	14%	0%
ICT	**38%**	4%	8%	17%	**50%**	4%	13%	17%	13%	8%	8%	21%	**29%**	17%	4%
Trucking	0%	0%	0%	0%	0%	**8%**	0%	**8%**	**8%**	0%	0%	**17%**	0%	**8%**	0%
Christchurch CBD	47%	53%	27%	**100%**	33%	33%	33%	60%	47%	**80%**	20%	**67%**	60%	7%	0%
Kaiapoi Town Centre	**57%**	**21%**	**29%**	14%	**21%**	14%	0%	7%	0%	14%	0%	0%	7%	0%	7%
Lyttelton Town Centre	**57%**	34%	34%	31%	**49%**	26%	9%	37%	20%	**43%**	11%	34%	29%	14%	9%
Entire Survey 2 Sample	**65%**	36%	39%	**47%**	64%	36%	22%	**47%**	33%	46%	16%	**49%**	44%	18%	33%

** Closure is temporary or permanent. ** The three most cited reasons for closure, per sector, are in bold highlighted cells.*

For Survey 2, organisations were asked about organisational disruption specifically caused by utilities and non-utilities. In both cases, organisations were presented with a list of possible disruptions and asked to state (yes or no) whether they were affected by disruption to this. Organisations that were affected were then asked to rank from 0 (not at all) to 3 (very) how disrupted they were to ascertain the degree to which they were affected. Results are in Tables 5-17 to 5-19.

For each sector, the three most cited disruptive factors are in bold highlighted cells. For non-utility disruption, the most commonly experienced form of disruption, except for Christchurch and Lyttelton, was change in staff emotional wellbeing (see Table 5-17). In the case of Christchurch CBD, this is likely because a lot of these organisations were closed for a period of time and survey respondents were not witness to the changes in emotional wellbeing of their colleagues at the time the survey was deployed. For Lyttelton, the town has a very strong sense of community and they reported that this led to people banding together and sharing the burden that was the earthquake. All the organisations from the Christchurch CBD were disrupted by damage to inventory or stock, damage to or closure of nearby buildings or organisations and also our organisation was located within a cordoned-off area. This again brings forward the issue of neighbour effects in CBDs and town centres as all the geographic locales as well as hospitality were affected by damage to or closure of nearby buildings or organisations. Lyttelton organisations were further affected by damage to or closure of nearby buildings or organisations and by non-structural damage (fittings damaged e.g. windows or light fixtures). More organisations from the FMCG (93%), trucking (83%) and building suppliers (82%) sectors reported customer issues as one of the most disruptive factors.

*Table 5-17: Per cent of organisations, by sector, reporting disruption from non-utilities**

Per cent of organisations reporting disruption from non-utilities																	
	Structural damage to building(s) (integrity of building compromised)	**Non-structural damage (fittings damaged e.g. windows or light fixtures)**	**Damage to equipment (non-computing)**	**Damage to computers**	**Damage to inventory or stock**	**Damage to ground surface**	**Damage to or closure of adjacent (next door) organisations or buildings**	**Damage to or closure of nearby buildings or organisations**	**Our organisation was located within cordoned-off area**	**Physical harm to employees**	**Supplier issues**	**Customer issues**	**Staff temporarily relocated**	**Staff permanently relocated**	**Staff did not feel safe returning to building**	**Changes in staff emotional wellbeing**	**Other**
Building Suppliers	45 %	**73 %**	45 %	9%	64 %	55 %	45 %	27 %	27 %	9%	64 %	**82 %**	36 %	0%	64 %	**82 %**	9%
Critical Infrastructure	56 %	**75 %**	63 %	50 %	38 %	**75 %**	38 %	44 %	38 %	13 %	**75 %**	**75 %**	56 %	25 %	56 %	**94 %**	13 %
FMCG	64 %	**71 %**	57 %	21 %	**79 %**	64 %	21 %	36 %	21 %	7%	57 %	**93 %**	36 %	14 %	57 %	10 0%	0%
Hospitality	**71 %**	57 %	57 %	43 %	**71 %**	43 %	57 %	57 %	**71 %**	14 %	43 %	43 %	43 %	43 %	43 %	57 %	14 %
ICT	29 %	**63 %**	**54 %**	33 %	38 %	25 %	33 %	38 %	25 %	8%	42 %	**54 %**	33 %	21 %	29 %	**67 %**	8%
Trucking	33 %	33 %	25 %	0%	25 %	**42 %**	33 %	17 %	0%	0%	33 %	**83 %**	17 %	0%	0%	**92 %**	8%
Christchurch CBD	**93 %**	**73 %**	60 %	20 %	10 0%	40 %	**93 %**	10 0%	10 0%	0%	67 %	**73 %**	47 %	53 %	60 %	60 %	0%
Kaiapoi	43 %	43 %	7%	14 %	50 %	36 %	29 %	**57 %**	29 %	0%	**57 %**	**57 %**	36 %	7%	29 %	**64 %**	0%
Lyttelton	**69 %**	**71 %**	37 %	26 %	57 %	46 %	60 %	**77 %**	31 %	3%	40 %	63 %	37 %	29 %	40 %	66 %	11 %
Entire Survey 2 Sample	57 %	**66 %**	46 %	26 %	57 %	48 %	48 %	55 %	36 %	6%	52 %	**72 %**	39 %	23 %	44 %	**79 %**	21 %

**The three most cited disruptive factors are in bold highlighted cells*

While Table 5-17 contains information on the percentage of organisations from each sector citing which factors affected their operations, Table 5-18 shows to what extent the affected organisations from each sector were affected by disruption to non-utilities (the computation is the same as that used in section 5.1). Again, the three highest degrees of effect, for each sector, are in bold highlighted cells. For instance, from Table 5-17, overall more organisations reported staff wellbeing as being a disruptive factor. However, in considering the extent to which this factor was disruptive, only the trucking sector found changes in staff emotional wellbeing to be very disruptive. The trucking sector also shows the lowest scores altogether for the degree to

which they were affected by different factors. Across the entire sample group, the factor whose disruption affected organisations the most was the organisation being located in a cordoned off area. This is prominent for the geographic sectors as they all had a lot of unreinforced masonry buildings that were damaged and demolished after 22 February 2011 earthquake. The hospitality organisations that were affected by being in a cordoned off area found this to be very disruptive. Only 38% of critical infrastructure organisations reported being affected by their organisation being in a cordoned off area (see Table 5-17). However, these affected critical infrastructure organisations found this to be very disruptive (see Table 5-18). These are organisations that had major infrastructure in Christchurch CBD and faced some difficulties even accessing their assets for repair.

*Table 5-18: Degree of effect to sector (for organisations that reported being disrupted) after disruption of non-utilities**

Degree of effect to sector after disruption of non-utilities (scores out of a possible maximum of 100)																	
	Structural damage to building(s) (integrity of building compromised)	Non-structural damage (fittings damaged e.g. windows or light fixtures)	Damage to equipment (non-computing)	Damage to computers	Damage to inventory or stock	Damage to ground surface	Damage to or closure of adjacent (next door) organisations or buildings	Damage to or closure of nearby buildings or organisations	Our organisation was located within cordoned-off area	Physical harm to employees	Supplier issues	Customer issues	Staff temporarily relocated	Staff permanently relocated	Staff did not feel safe returning to building	Changes in staff emotional wellbeing	Other
Building Suppliers	38	**41**	29	0	33	37	33	33	60	22	50	**71**	50	22	33	**42**	17
Critical Infrastructure	**77**	56	60	58	63	47	57	50	**76**	25	53	64	67	**73**	50	43	33
FMCG	64	42	47	6	**67**	43	50	**72**	**67**	8	50	56	33	33	40	52	0
Hospitality	**78**	73	73	**75**	**78**	**75**	**80**	**80**	83	50	42	53	56	67	73	61	56
ICT	45	53	44	**56**	**56**	50	24	25	50	8	45	**57**	50	38	48	44	11
Trucking	33	17	7	0	33	20	8	0	0	0	**39**	**67**	17	0	0	**37**	0
Christchurch CBD	**90**	70	67	43	79	46	**92**	**90**	**100**	0	55	87	57	87	71	75	33
Kaiapoi	**59**	19	8	40	29	33	44	57	**57**	0	52	50	**56**	25	33	48	0
Lyttelton	71	68	62	42	73	58	67	65	77	0	67	84	64	56	58	57	75
Entire Survey 2 Sample	**62**	49	44	36	57	45	51	52	**63**	13	50	**65**	50	45	45	51	25

** The three highest degrees of effect, for each sector, are in bold highlighted cells. All scores out of a possible maximum of 100.*

For interruption caused by the disruption of utilities (Table 5-19), more critical infrastructure organisations reported being affected by disruption of all the alternatives presented. This is because of the closely coupled location of infrastructure where one service needing repair means all the other utilities are affected. For instance, the disruption to utilities like roads and gas meant that the repair and remediation work to be carried out was slowed down as they were unable to get to repair sites or could not access the sites until electricity, gas or water had been turned off. This required considerable coordination from the lifeline utilities in the greater Christchurch area and was made easier by the fact that they had good pre-existing relationships from the regular Engineering Lifelines Group meeting (see section 4.2.2). Disruption to utilities after the 22

February 2011 earthquake in some cases also affected search and rescue as rescue teams had to ensure that all utilities would not be hazards to operations.

More organisations reported being affected by disruption to road networks, communications and water than by disruption to sewerage and electricity. For the Christchurch CBD sector affected organisations reported being *very* disrupted. This is a result of the extensive damage caused by ground motion from the earthquake[32].

[32] The 22 February earthquake had some of the highest peak ground accelerations ever recorded for an earthquake of Mw 6.3

Table 5-19: Disruption (by per cent of sector) and degree of effect (for organisations that reported being disrupted) - utilities

Disruption and extent of disruption to utilities										
	Affected by disruption					Level of impact caused by disruption				
	Water supply disruption	Sewage or effluent disruption	Electricity disruption	Communications disruption	Road network disruption	Water supply disruption	Sewage or effluent disruption	Electricity disruption	Communications disruption	Road network disruption
Building Suppliers	64%	45%	64%	73%	55%	71	62	67	59	67
Critical Infrastructure	81%	81%	69%	69%	81%	72	59	69	63	67
FMCG	64%	36%	50%	64%	79%	67	58	33	47	58
Hospitality	71%	57%	71%	71%	71%	83	73	83	78	83
ICT	58%	42%	50%	46%	58%	45	53	62	47	48
Trucking	33%	25%	42%	42%	67%	42	50	40	50	71
Christchurch CBD	73%	73%	80%	87%	80%	100	100	100	100	100
Kaiapoi Town Centre	29%	29%	21%	57%	50%	33	22	33	50	50
Lyttelton Town Centre	66%	46%	69%	49%	63%	76	82	79	85	89
Entire Survey 2 Sample	63%	50%	59%	61%	69%	65	62	63	64	70

5.3 Survey 3[33] (deployed 12 March 2012 to 19 May 2012)

Survey 3 was designed to bring together data on the after-effects of the earthquakes 18 months after the initial 4 September 2010 earthquake and 12 months after the more destructive 22 February 2011 earthquake. Survey 3 was also intended to determine how organisations were affected by subsequent aftershocks, such as those on 13 June and 23 December 2011. It should be kept in mind that results presented for Survey 3 are only for organisations that participated in Survey 3 (see tables 5-1 and 5-2 for survey response rates). Additionally, results for the hospitality sector are not reported in this section because of the small number of responses received from the sector for Survey 3. Some organisations chose not to participate further after Survey 1 and Survey 2.

In Survey 3, organisations were asked to state whether they were open or trading, permanently closed or intended to re-open. Table 5-20 has the organisational responses by sector showing organisations that were open or trading or those that intended to re-open. Only organisations from the CBD and Town Centres reported that they were still closed but intended to re-open. Reasons for those intending to re-open included the building of new premises and waiting for issues to do with their building to be resolved before it could be re-occupied.

[33] It should be noted that the hospitality sector has been omitted from the numerical results presentation for Survey 3 because of the low participation of organisations from the sector.

*Table 5-20: Organisations intending to re-open, open/trading or permanently closed**

Organisations intending to re-open, open/trading or permanently closed		
	Intend to re-open	**Open/trading**
Building Suppliers	0%	100%
Critical Infrastructure	0%	100%
FMCG	0%	100%
ICT	0%	100%
Trucking	0%	100%
Christchurch CBD	20%	80%
Kaiapoi Town Centre	13%	87%
Lyttelton Town Centre	40%	60%
Entire Survey 3 Sample**	11%	89%

**Owing to rounding, for this and subsequent tables, numbers might add up to just under or just over 100%*
*** Hospitality organisations not included*

The Canterbury earthquakes were unusual in that they went on for as long as they did and that there were more than four events with a magnitude greater than M_W 6. In response to an open ended question in Survey 3, organisations reported that the continuing earthquakes made it difficult to plan and were also very disruptive as after every earthquake more than M_W 5.5 buildings were evacuated and had to be inspected[34]. Most organisations did not have dedicated geotechnical or structural engineers to check and certify buildings immediately after each earthquake. This was a bottleneck in the system. Machinery and other equipment also had to be shut down and inspected which affected many production lines. The FMCG manufacturing organisations reported that one of their challenges was the stopping and restarting of production lines which can take a great deal of time. Another personnel bottleneck was the availability of insurance assessors and adjustors. As some of the buildings that had to be inspected were schools, this meant that parents had to go and pick up children. This caused even more

[34] The reason for the evacuation of buildings after a Mw 5.5 earthquake is unclear. It is possible that this came about because of the Ministry of Education advising that school should be evacuated and buildings checked after each Mw 5.5 earthquake. The evacuation of schools meant that parents needed to leave work and collect their children.

disruption as they could sometimes not return to the office or if they did had on their minds the welfare of their families.

In the aftershock sequence, overall more organisations (31%) reported being affected by the 13 June 2011 aftershock than by either the 26 December 2010 (3%) or 23 December 2011 (26%) aftershocks. The sector with the most organisations affected by both the 13 June and 23 December 2011 aftershocks was critical infrastructure. The continuing aftershocks made it difficult to renew or get new building insurance or contract works insurance for builders as insurance companies weighed up the risks.

Considering the extended closure of the CBD and the difficulty in getting buildings constructed or repaired as a result of the aftershocks, it is interesting to note that over two-thirds of organisations participating in Survey 3 did not relocate (see Table 5-21). However, Christchurch CBD at 80%, building suppliers (43%) and Lyttelton (40%) were the sectors with the most organisations reporting relocating. This emphasises the localised nature that was characteristic of the 22 February 2011 earthquake; the more devastating effects of the earthquake manifested in the CBD, Lyttelton and in the eastern suburbs of Christchurch. This meant the organisations that were able could relocate and work from different parts of the greater Christchurch area. This was also made possible by the quick restoration or non-disruption of utilities to many parts of Christchurch (Giovinazzi & Wilson, 2012). Additionally, this means that prior to the earthquakes, Christchurch had slack building resources in areas outside the CBD that could be used as commercial accommodation.

*Table 5-21: Organisations relocated or not after any of the earthquakes***

Organisations relocated or not after any of the earthquakes		
	No	**Yes**
Building Suppliers	57%	43%
Critical Infrastructure	71%	29%
FMCG	80%	20%
ICT	77%	23%
Trucking	100%	0%
Christchurch CBD	20%	80%
Kaiapoi Town Centre	88%	13%
Lyttelton Town Centre	50%	40%
Entire Survey 3 Sample	68%	31%

***Not all organisations answered this question; totals may not add up to 100%*

According to Alesch et al (2001) and Sheffi (2007) disaster sometimes necessitates a change in an organisation's core business. This might be because their goods and services are no longer needed or there is a new market opportunity due to the disaster. In Survey 3, all organisations indicated they were still in the same line of business. However 16% of all organisations reported adding a new product line to their existing one(s). These figures are for organisations who took the opportunity to make alterations to product lines after the earthquakes. However, it is not known how many would have taken this step if the earthquakes had not occurred. Half of the organisations that added a new product line were from Lyttelton. Further, 21% of organisations reported that they had wanted to make changes (prior to the earthquakes) and the time after the earthquakes was right and/or they realised the business had to change to survive.

In relation to this, an organisation, or even its regular supplier, changing operations as a result of the earthquakes may lead to the organisation requiring new suppliers. Alternatively an organisation's suppliers may have been unable to meet their supply quota after the earthquakes which may have led to a need for new suppliers. An organisation's supply chain includes other organisations that may or may not have been affected by the earthquakes. Table 5-22 contains information on how many organisations reported the need to use new suppliers a year after the

22 February 2011 earthquake. More critical infrastructure organisations reported using new suppliers than any other sector. Interviews with some of the critical infrastructure organisations revealed that this was due to their regular suppliers not carrying the amount of supplies required for earthquake repairs.

*Table 5-22: Organisations reporting the need to use new suppliers***

Organisations reporting the need to use new suppliers		
	No	**Yes**
Building Suppliers	86%	14%
Critical Infrastructure	43%	57%
FMCG	80%	20%
ICT	92%	8%
Trucking	83%	17%
Christchurch CBD	60%	40%
Kaiapoi Town Centre	88%	13%
Lyttelton Town Centre	70%	20%
Entire Survey 3 Sample	76%	23%

***Not all organisations answered this question; totals may not add up to 100%*

The sequence of earthquakes in Canterbury and the cost of the disaster (Munich Re, 1999) caused massive insurance settlement delays. In Survey 3 organisations were asked if they had lodged insurance claims, if their insurance cover was adequate and if insurance claims had been settled in full following the 22 February 2011 earthquakes. Results are in Table 5-23. More organisations from Lyttelton, trucking and Kaiapoi did not lodge insurance claims after the 22 February 2011 earthquake than from other sectors. Some organisations reported that the reason for this was because the insurance excess was more than the cost of the damage incurred. For Lyttelton however, the sector had the most organisations (40%) report that they did not have insurance cover. Most of the organisations in the Lyttelton sample are small- to medium-sized enterprises (SMEs). Also in the Lyttelton sample are some not-for-profit organisations. Both the

SMEs and the not-for-profits reported that they could not afford the insurance premiums and decided to go without.

*Table 5-23: Insurance type***

Insurance type							
	Following the 22 February 2011 earthquake:						
	did your organisation lodge an insurance claim?		was your insurance cover/policy adequate?			has your insurance claim been settled in full?	
	No	Yes	No	No Insurance cover	Yes	No	Yes
Building Suppliers	43%	57%	14%	29%	57%	43%	14%
Critical Infrastructure	14%	86%	0%	14%	86%	43%	14%
FMCG	40%	60%	20%	0%	60%	40%	40%
ICT	46%	46%	8%	0%	62%	15%	38%
Trucking	67%	33%	33%	0%	50%	33%	0%
Christchurch CBD	40%	60%	20%	20%	20%	60%	0%
Kaiapoi Town Centre	50%	50%	13%	13%	50%	38%	13%
Lyttelton Town Centre	70%	30%	0%	40%	50%	40%	0%
Entire Survey 3 Sample	47%	52%	11%	15%	56%	35%	18%

***Not all organisations answered this question; totals may not add up to 100%*

Other documented effects of disaster include changes to cash flow, revenue and profits (West & Lenze, 1994). These changes, positive or negative, also have ripple effects such as organisations expanding or contracting operations or the hiring or laying off of staff. In order to determine the extent to which the earthquakes in Canterbury affected business operations over time, owners were asked about changes to cash flow (Table 5-24), revenue (Table 5-25) and staffing (Tables 5-

26 and 5-27). Organisations were also asked to indicate whether their businesses were worse off, better off or about the same compared to before the earthquakes.

Organisations from the FMCG (80%) and trucking (66%) sectors were more likely to indicate *excellent* or *good* cash flow while more organisations from critical infrastructure (57%) reported having *good* cash flow. The building suppliers and Christchurch CBD sectors stood out with more organisations, 43% and 40% respectively reporting poor cash flow. The sectors have slightly different reasons for this, however, all related to not having enough custom. The building suppliers (mainly those selling products like floors and roofs) spoke of still not profiting because of the slow start to rebuild work. The CBD organisations stated that with the relocation of major employers out of the CBD and the drop in foot traffic, there were not enough customers. It is worth remembering that some of the organisations that were in the CBD prior to the earthquakes may not return there.

*Table 5-24: Organisational cash flow***

Organisational cash flow						
	With your organisation's cash flow in mind, which of the following applies:					
	Excellent	Good	Satisfactory	Poor	Very Poor	Don't
Building Suppliers	0%	14%	43%	43%	0%	0%
Critical Infrastructure	14%	57%	29%	0%	0%	0%
FMCG	40%	40%	20%	0%	0%	0%
ICT	15%	15%	46%	8%	0%	8%
Trucking	33%	33%	33%	0%	0%	0%
Christchurch CBD	0%	20%	40%	40%	0%	0%
Kaiapoi Town Centre	13%	38%	13%	25%	13%	0%
Lyttelton Town Centre	20%	20%	30%	20%	0%	0%
Entire Survey 3 Sample	16%	27%	34%	16%	2%	2%

***Not all organisations answered this question; totals may not add up to 100%*

In comparison to results from Surveys 1 and 2 (see Tables 5-7 and 5-14 respectively), the building suppliers sector was still the sector with the most organisations reporting a decrease in revenue after Survey 3. Some of the organisations from the building suppliers sector however, commented that business has picked up and this will be reflected on the balance sheet in the months following. Forty per cent of FMCG organisations reported a drop in revenue. This is attributed to pricing changes, i.e. decreases, which led to lower profit margins on many product lines after the earthquakes. Organisations reported reducing prices, as a short-term measure, in order to attract customers (see section 7.5 for more detail). In contrast, organisations in the ICT sector that reported no change or an increase in revenue ascribed this to the continued growth of their sector and also to having a customer base outside of the Canterbury region and New Zealand.

*Table 5-25: Organisational revenue change**

Organisational revenue change			
	Decreased	**No Change**	**Increased**
Building Suppliers	71%	0%	29%
Critical Infrastructure	57%	0%	43%
FMCG	40%	20%	40%
ICT	15%	38%	46%
Trucking	17%	50%	33%
Christchurch CBD	60%	0%	40%
Kaiapoi Town Centre	50%	13%	38%
Lyttelton Town Centre	20%	30%	40%
Entire Survey 3 Sample	37%	21%	40%

**Not all organisations answered this question; totals may not add up to 100%*

Tables 5-26 and 5-27 show the staffing changes in organisations after the earthquakes. Organisations reported that they tried to ensure that staff lay-offs were a last resort after the earthquakes. One reason provided was that in the period of uncertainty the workplace should provide some security. Additionally, organisations also did not want to lose staff through their leaving voluntarily. Some organisations offered to relocate staff and their families to other offices in New Zealand as this meant they would still be with the organisation. Some respondents stated that this was also good for the morale of the teams in the organisation.

However, some staff still chose to leave voluntarily. Organisations from FMCG (80%), critical infrastructure and building suppliers (both at 71%) reported staff leaving voluntarily. The most frequent reason for this was the inability to cope with the continuing aftershocks as well as family pressure to leave the greater Christchurch region. It is possible that the larger organisations with more staff would have proportionately higher numbers of staff leaving; however analysis of the data did not indicate this.

*Table 5-26: Full-time staff voluntarily leaving***

	Full-time staff voluntarily leaving organisation after the earthquakes	
	No	**Yes**
Building Suppliers	29%	71%
Critical Infrastructure	29%	71%
FMCG	0%	80%
ICT	38%	46%
Trucking	50%	50%
Christchurch CBD	20%	60%
Kaiapoi Town Centre	50%	25%
Lyttelton Town Centre	70%	0%
Entire Survey 3 Sample	39%	47%

***Not all organisations answered this question; totals may not add up to 100%*

Furthermore, some organisations reported on redundancy and hiring changes. Organisations from the building suppliers sector more frequently reported hiring personnel. This was accounted for by the building suppliers stating that they were hiring in preparation for the rebuilding work that would commence and the demand for product that they would have to meet. However, building supplier organisations that supply heavy machinery hired people because they had experienced a rise in demand for their machinery.

*Table 5-27: Staff redundancy and hire***

	Staff redundancy		Staff hire	
	No	Yes	No	Yes
Building Suppliers	71%	29%	29%	71%
Critical Infrastructure	71%	14%	43%	57%
FMCG	100%	0%	40%	40%
ICT	100%	0%	46%	54%
Trucking	100%	0%	50%	50%
Christchurch CBD	80%	20%	40%	40%
Kaiapoi Town Centre	75%	0%	25%	25%
Lyttelton Town Centre	80%	0%	70%	10%
Entire Survey 3 Sample	85%	6%	45%	42%

***Not all organisations answered this question; totals may not add up to 100%*

Organisations were asked to describe the performance of the organisation in comparison to pre-earthquake levels. Results are contained in Table 5-28. More organisations from the building suppliers and Christchurch CBD sectors reported their organisations as being significantly worse off, compared to pre-earthquake levels, than any other sectors. For the building suppliers sector, this is interesting because the sector was already facing reduced sales prior to the earthquakes. Importantly, just under half (45%) of the organisations surveyed said their organisation was significantly or slightly worse off in comparisons to pre-earthquake performance.

*Table 5-28: Self-report performance of organisations pre- and post-earthquake***

Performance of organisations pre- and post-earthquake					
	With the earthquakes in mind, is your organisation:				
	Significantly worse off	Slightly worse	Same	Slightly better	Significantly better
Building Suppliers	57%	14%	0%	14%	14%
Critical Infrastructure	14%	43%	14%	29%	0%
FMCG	20%	20%	0%	40%	20%
ICT	0%	23%	46%	31%	0%
Trucking	0%	33%	17%	50%	0%
Christchurch CBD	40%	20%	20%	20%	0%
Kaiapoi Town Centre	25%	38%	13%	13%	13%
Lyttelton Town Centre	20%	10%	30%	30%	10%
Entire Survey 3 Sample	19%	26%	21%	27%	6%

***Not all organisations answered this question; totals may not add up to 100%*

5.4 Sectoral challenges

In all three surveys deployed, organisations were asked what particular challenges their organisations faced after the earthquakes. In all three instances, the biggest challenge across all sectors was the wellbeing of staff. Organisations reported increased stress levels and drops in motivation. This was partly a result of the ongoing earthquakes and also because people had to deal with relocation, repairs, restoration or demolition of their properties on top of the insurance and other paperwork that needed to be done. Table 5-29 contains complete results of each sector's challenges.

From Table 5-29, after Survey 1, Kaiapoi and Christchurch CBD both identified as challenges reduced customers numbers and reduced customer spending. The hospitality sector also listed these as some of their challenges. However, the CBD and Town Centres were also subject to neighbour effects. This was a concern for all three geographic locales in all the surveys. From Surveys 2 and 3, common to Lyttelton and Kaiapoi were comments from not-for-profits about difficulty maintaining their profiles in the community as people's time was taken up dealing with

the consequences of the earthquakes. After Survey 3, it emerged that the trucking and critical infrastructure sectors were in competition for some of the same human resources as a result of a shortage of that particular skillset.

The critical infrastructure sector listed damage to their infrastructure, especially the buried infrastructure, as a considerable challenge. This continued throughout the different survey periods and was compounded by continued damage due to aftershocks and having to ensure that infrastructure was assessed after every significant aftershock. Also challenging was planning for and implementation of seismic retrofitting measures while not knowing where people would relocate to as a result of land use planning decisions such as the residential zoning. Critical infrastructure organisations stood out in particular for staff wellbeing because of the extended hours their staff worked to effect repairs to damaged infrastructure.

After both Surveys 1 and 2, those ICT organisations with local customers detailed having trouble accessing their customers, especially those who had been located in the Christchurch CBD at the time of the 22 February 2011 earthquake. Also, due to the mobile nature of some of their work, some of these ICT organisations wrote of worrying about the safety of their staff in case of earthquakes as they worked from customers' alternative premises such as private homes which may not have been checked for earthquake resistance. For ICT organisations with customers outside the Christchurch region and New Zealand, one of their challenges was reassuring clients that they could still deliver.

Table 5-29: Sectoral biggest challenges after Surveys 1, 2 and 3

Sector	Challenges Survey 1	Challenges Survey 2	Challenges Survey 3
All sectors	→ ***Staff wellbeing***	***Staff wellbeing***	→ ***Staff wellbeing***
Building Suppliers	→ *Uncertain demand* → *Not enough equipment* → *Cancellation of pre-earthquake work* → *Cash flow* → *Insurance*	→ *Uncertain demand* → *Cash flow*	→ *Insurance/EQC* → *Uncertain demand* → *Reduced sales, cash flow*
Critical Infrastructure	→ *Damaged infrastructure* → *Increased demand for services* → *Effect of continuing aftershocks on infrastructure* → *Staff long hours*	→ *Effects of tightly coupled infrastructure* → *Continued repair and restoration of large parts of infrastructure* → *Estimating level of damage to buried infrastructure* → *Continual checking of large bit of infrastructure due to aftershocks* → *Staff long working hours* → *Balance earthquake work with business-as-usual*	→ *Uncertainty, planning ahead difficult* → *Network retrofit for better seismic performance* → *Balance earthquake work with business-as-usual*
FMCG	→ *Supply and demand issues* → *Loss of CBD customers*	→ *Supply and demand oscillation*	→ *Pricing low, reduced profit margin*
Hospitality	→ *Reduced discretionary spending* → *Cordons*	→ *Access to premises* → *Reduced discretionary spending* → *Insurance*	
ICT	→ *Dealing with affected customers* → *Accessing affected customers* → *Dealing with*	→ *Skills shortage* → *Customer engagement for local ICT organisations* → *Dealing with customers outside the region*	→ *Skills shortage* → *Staff retention* → *Managing workload*

	customers outside the region	→ *Increased demand, managing workloads*	
Trucking	→ *Erratic demand* → *Damaged infrastructure* → *More work*	→ *Damaged infrastructure affecting maintenance and cost adding to travel time* → *Erratic demand, uncertainty of work* → *More work* → *Staff retention*	→ *Damaged infrastructure still affecting maintenance and cost adding to travel time* → *More work* → *Traffic management issues with reduced infrastructure* → *Skills shortage*
Christchurch CBD	→ *Decrease in customer number for various reasons* → *Customer perception* → *Cordons and damage to infrastructure* → *Decrease in customer spending* → *Cash flow*	→ *Insurance* → *Finding premises to relocate to* → *Relocating* → *Cash flow* → *Accessing premises inside cordon*	→ *Customer awareness that shops are trading*
Kaiapoi Town Centre	→ *Dealing with emotional customers* → *Neighbour effects* → *Reduced discretionary spending*	→ *Neighbour effects* → *Reduced discretionary spending* → *Uncertainty*	→ *Decreased customer numbers* → *Decreased sales*
Lyttelton		→ *Insurance* → *Motivation and patience* → *Staff and customer wellbeing* → *Available premises* → *Building tagging, access and repairs*	→ *Uncertain rebuilding plans*

5.4.1 **Synopsis of results - temporal trends across sectors**

There are some differences in how organisations and sectors were affected after each survey. These differences are more apparent mainly between Surveys 1 and 2 because some of the questions were repeated in the two surveys. Some of these differences were also because of the

very different characteristics of the 4 September 2010 and 22 February 2011 earthquakes (see chapter 1 for more detail).

More building supplier organisations closed temporarily after Survey 1 than after Survey 2. However, fewer organisations from FMCG, hospitality and trucking reported temporary or permanent closure after Survey 1. After Survey 2, there were also less organisations reporting closure in Kaiapoi and more organisations closed in the CBD. In keeping with the reported increased workload, more trucking and critical infrastructure organisations reported working longer hours after Survey 2. In Survey 1, these were also the 2 sectors that worked more hours than any other.

Table 5-30 shows the sectoral revenue changes after Surveys 1 and 2. With each survey, there was an increase in the percentage of building supplier organisations reporting revenue losses. This is in addition to the building suppliers sector reporting a downward trend in revenue for the period before the earthquakes (see section 4.2.1). Some organisations reported that this continuing pattern of reduced revenue was a hindrance to recovery as they did not have sufficient cash reserves post-earthquakes. In the disaster literature, (Alesch et al., 2009; Olshansky & Johnson, 2012; Quarantelli, 1999; Rose & Lim, 2002) it has been documented how recovery can be a long, slow process and can be linked to the amount of resources an organisation has access to in the recovery period as well as the effective use of those resources. Effective utilisation of resources (Gladwell, 2000; Hummel et al., 2007) ensures that they are used in the phase of recovery when they are most needed (see chapter 6.8.6).

Table 5-30: Comparison of sectoral revenue changes after 4 September 2010 earthquake (data from Survey 1) and 22 February 2011 earthquake (data from after Survey 2)

Comparison of sectoral revenue changes after 4 September 2010 earthquake (data from Survey 1) and 22 February 2011 earthquake (data from after Survey 2)						
	Revenue has decreased		No change		Revenue has increased	
	After 4 September 2010 earthquake (Survey 1)	After 22 February 2011 earthquake (Survey 2)	After 4 September 2010 earthquake (Survey 1)	After 22 February 2011 earthquake (Survey 2)	After 4 September 2010 earthquake (Survey 1)	After 22 February 2011 earthquake (Survey 2)
Building Suppliers	59%	82%	23%	0%	14%	18%
Critical Infrastructure	18%	38%	50%	25%	23%	19%
FMCG	16%	29%	62%	29%	16%	43%
Hospitality	67%	86%	15%	0%	19%	29%
ICT	20%	13%	70%	54%	10%	33%
Trucking	38%	42%	46%	25%	17%	33%
Christchurch CBD	77%	87%	19%	0%	3%	20%
Kaiapoi Town Centre	64%	14%	28%	36%	8%	21%
Lyttelton	Did not participate	60%	Did not participate	20%	Did not participate	11%
Entire Survey 1 Sample	45%	47%	39%	24%	13%	24%

In contrast, the FMCG sector had a higher percentage of organisations with revenue increases in Survey 2 than in Survey 1. There was a slight dip in Survey 3 compared to Survey 2. In personal communication with a FMCG business leader, he pointed to the population shift after the earthquakes as a challenge for the sector: both in customer numbers and in long-term planning. He noted that some FMCG retail locations had far lower numbers than pre-earthquake while some had more. The hospitality sector also had a larger percentage of organisations reporting revenue increases from Survey 1 to Survey 2. Considering the timing of Survey 2, there are two possible reasons for this. The first is that they had increased revenues because of the Rugby World Cup (hosted by New Zealand) and the second is that the open hospitality associations profited from others being closed. Trucking and Kaiapoi also had more businesses experience

revenue increases after Survey 2. For trucking this is consistent with the increased post-earthquake work load they reported. In Kaiapoi this may be a result of the joint marketing campaign the organisations embarked on, profiting from the closure of the Christchurch CBD and local customer loyalty. Kaiapoi was also the only sector where there were more businesses reporting no change to their revenue after Survey 2. There were less Lyttelton organisations reporting revenue decreases after Survey 3. The trends for revenue changes are displayed in the form of the recovery rate coefficient (RRC) discussed in chapter 7: significant contributors to recovery.

After Survey 2, more organisations cited insurance as one of their means of recovery finance compared to after Survey 1. After Survey 1, some organisations pointed to not filing insurance claims because the damage was less than the excess. The increase in reports of insurance as a means of recovery finance is likely because more organisations were affected by the 22 February 2011 than by the 4 September 2010 earthquake (see Table 5-11) and the more severe damage after the 22 February 2011 earthquake. However, from analysis of sectoral biggest challenges, insurance was cited more frequently as a challenge after Survey 2. The primary reason for this is likely the delay in resolving insurance issues. Interestingly, hospitality had an increase in the number of organisations using *money borrowed from family or friends* to finance their recovery. Berger (1998) and Avery (1998) found that in small organisations it is often difficult for owners to separate their personal assets from organisational assets. In such instances, it is not easy for the firm to get a loan from lending agencies. In this thesis, the size of the organisation is just one of the attributes investigated. Therefore, a separate more detailed analysis of the effects of recovery based on organisation size is contained in appendix I.

The biggest challenge faced by all sectors was staff wellbeing. Organisations noted that one year after the 22 February 2011 earthquake, staff were more likely to suffer fatigue. Some organisations commented on the increase in frequency of mistakes made by tired staff. Organisations reported that they took measures such as booking holiday getaways, away from Christchurch, for staff members to help with the problem of fatigue. In other cases, organisations offered staff the option of working from alternate locations instead of having staff leave. There is more discussion on staff wellbeing in chapters 6 and 10.

Another way in which organisations can be affected after disaster is through staff retention. Over the three surveys, the numbers of staff taken on and let go increased for the building suppliers sector. This was the general trend for the critical infrastructure, FMCG and trucking sectors. These sectors reported requiring more staff for the increased workload after the earthquakes. More hospitality and CBD organisations had staff redundancies from survey to survey. They also had less hires over this time period. Organisations that had staff redundancies reported this being due to their extended closure. The ICT sector had an increase in workforce between Surveys 2 and 3. Keeping in mind ICT sector reports of a continuing skills shortage, it is unclear where the hires were from. Trucking had more staff hires from Survey 1 to Survey 2 and experienced a very slight drop between Surveys 2 and 3 in businesses reporting hiring staff. Kaiapoi had a slight increase in organisations reporting hires while Lyttelton showed a drop in number of organisations reporting redundancies after Survey 3.

In an illustration of neighbourhood effects, a substantial proportion of CBD and hospitality organisations reported one of their biggest causes of disruption to be *damage to or closure of nearby buildings* as well as *damage to adjacent buildings*. Neighbourhood effects are some of the ecological factors that can affect the recovery of organisations after disaster. Some of these effects are discussed in chapters 7 and 8. From Survey 1 to Survey 2, there was also a rise in how affected organisations were by utility disruption. This again shows the amount of damage caused by the 22 February 2011 earthquake to infrastructure compared to the 4 September 2011 earthquake.

5.5 Organisational resilience using the Benchmark Resilience Tool (BRT)

Organisational researchers have long puzzled over what particular organisational traits enable some organisations to survive crisis better than others and if it would be possible to ascertain business survival before crisis or disaster struck. This has led to the attempt to quantify the resilience of organisations.

The second part of all the surveys deployed for this investigation contained questions from the Benchmark Resilience Tool (BRT) regarding the resilience of the organisation (there is more discussion on the BRT in chapters 2 and 10). The BRT contains items (questions) to which respondents are asked to indicate a level of agreement (strongly agree to strongly disagree) on a

5-point Likert scale. The statements together form the 13 indicators of organisational resilience shown in Figure 5-1. The BRT gives a single index score which is the average of the 13 indicators of organisational resilience. The two factors of organisational resilience named *planning* and *adaptive capacity* are also arrived at by the averaging of the indicators they are comprised of. The planning factor contains five indicators of organisational resilience while the adaptive capacity factor contains eight of the 13 resilience indicators.

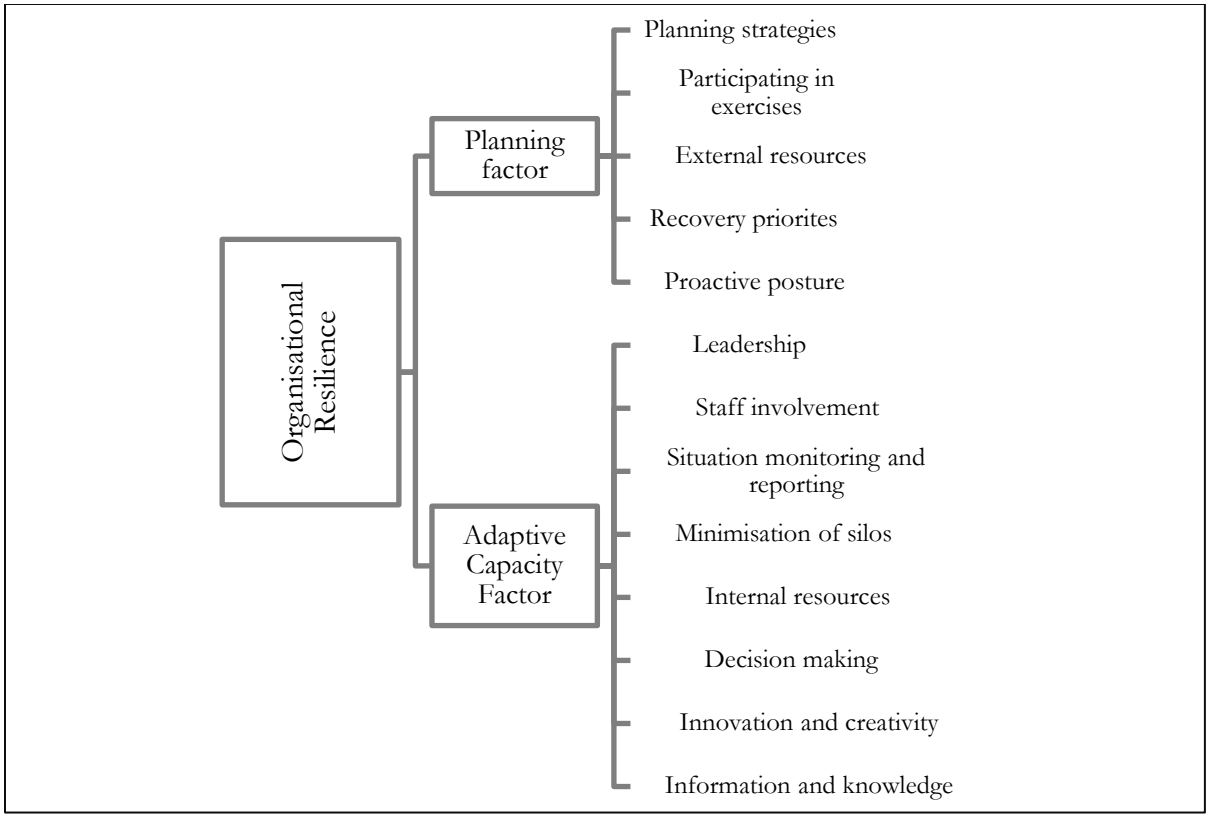


Figure 5-1: Indicators of organisational resilience contained in the Benchmark Resilience Tool (BRT-53)

Using the BRT, the scores for the factors or overall organisational resilience are arrived at via the formula:

Planning [Average of $P_{i1}+ P_{i2}.....P_{i5}]/3*100$
Adaptive capacity = [Average of $AC_{i1} + AC_{i2} +.....AC_{i8}]/3*100$
Overall organisational resilience = [Planning factor score + Adaptive capacity factor score]/2
$= \left[[(P_{i1}+ P_{i2}.....P_{i5})]/5*100 + [(AC_{i1} + AC_{i2} +.....AC_{i8})]/8*100\right]$

$_i$ is the indicator
P = planning factor
AC = adaptive capacity factor

Equation 5-2: Calculation for Benchmark Resilience Tool (BRT) overall organisational resilience and factors of resilience

It is important to note that the development of the BRT was done with the participation of organisations during business-as-usual. Organisations in the greater Christchurch area used the BRT during a crisis period. Additionally, the questionnaire was designed for self-completion by respondents. This means that there is the possibility of self-reporting bias as various respondents may have interpreted questions or phrases differently. Organisations may also be motivated to present their performance in a positive light, especially in the level of resilience. This is a constraint for any survey that relies on self-reporting and results must be interpreted with this in mind.

The full version of the BRT contains 53 items which when deployed in combination with questions investigating earthquake effects to organisations lengthened the questionnaires considerably. This called for a shorter version of the BRT which was used in Surveys 1 and 3. For more information on the development and validation of the shorter version of the BRT please see Whitman et al (2014). For all the items contained in the BRT refer to appendix F.

The sectoral organisational resilience results computed after use of the BRT are presented in Table 5-31 for Survey 1, Table 5-32 for Survey 2 and Table 5-33 for Survey 3. Individual sectoral indicator scores for all surveys are shown in appendix F. Also, in chapter 10, the disaster resilience of organisations is discussed and some detail on the possible reasons for difference in sectoral resilience scores is provided.

*Table 5-31: Survey 1 sectoral resilience scores using the Benchmark Resilience Tool (BRT)**

Survey 1 sectoral resilience scores using the Benchmark Resilience Tool (BRT)			
	Average Sectoral Planning Factor Score	**Average Sectoral Adaptive Capacity Factor Score**	**Average Sectoral Resilience Score**
Building Suppliers	54%	63%	59%
Critical Infrastructure	84%	84%	84%
FMCG	69%	80%	75%
Hospitality	59%	70%	64%
ICT	57%	73%	65%
Trucking	67%	78%	72%
Christchurch CBD	64%	73%	68%
Kaiapoi	60%	70%	65%
Entire Survey 1 Sample	64%	74%	69%

**Lyttelton Town Centre organisations did not take part in Survey 1.*

After the 4 September 2010 earthquake, the sectors with the highest resilience scores (measured using the BRT) were critical infrastructure, FMCG and trucking with scores of 84%, 75% and 72% respectively. These were also the sectors to have the highest scores for both the planning and adaptive capacity factors. The sectors with the lowest resilience scores were building suppliers and hospitality with resilience scores of 59% and 64% respectively.

For Survey 2, the sector with the highest resilience score was again critical infrastructure (54%) followed by trucking with 52%. Kaiapoi was the sector with the third highest score at 51%. Notably, when sectoral resilience scores are compared between Surveys 1 and 2, the direction for all sectors is down. Figure 5-2 (and appendix F) has a graphical representation of the difference in sectoral resilience score between Surveys 1 and 2. Additionally, the spread of the resilience scores after the 22 February 2011 earthquake was narrower across and between all sectors after Survey 2. This is likely because of the level of effect to organisations of the 22 February 2011 earthquake (more detail in chapter 10). Resilience is a trait that can wear down depending on circumstances and that needs to be maintained, rebuilt or renewed constantly. Sutcliffe and Vogus (2003) in their work on organisational resilience state the same.

Table 5-32: Survey 2 sectoral resilience scores using the Benchmark Resilience Tool (BRT)

Survey 2 sectoral resilience scores using the Benchmark Resilience Tool (BRT)			
	Average Sectoral Planning Factor Score	**Average Sectoral Adaptive Capacity Factor Score**	**Average Sectoral Resilience Score**
Building Suppliers	46%	47%	47%
Critical Infrastructure	52%	56%	54%
FMCG	47%	51%	49%
Hospitality	42%	43%	43%
ICT	50%	50%	50%
Trucking	51%	53%	52%
Christchurch CBD	49%	52%	50%
Kaiapoi Town Centre	50%	52%	51%
Lyttelton Town Centre	44%	44%	44%
Entire Survey 2 Sample	48%	50%	49%

After Survey 3, the organisational resilience scores were generally higher than after Survey 2. The scores after Survey 3 were comparable to those obtained after Survey 1. Also with Survey 3, the critical infrastructure sector had the highest resilience scores (79%). This was followed by trucking with 71% and Kaiapoi with 70%. The increase in organisational resilience scores from Survey 2 to Survey 3 could be attributed to organisations moving from the acute phase of a crisis to the very early stages of recovery that are less chaotic. It is also possible that the scores increased because surviving organisations took part in later parts of the research. However, on being contacted for participation in Survey 3, all of the organisations that declined were still operational.

With the deployment of the BRT occurring after the earthquakes, respondents were being asked to reflect retrospectively on the running of their organisation. It is possible that after coming through the earthquakes comparatively well, organisations may overestimate how well they performed both during and after the response and early recovery phases of the crisis. This magnification of the organisation's capabilities after surviving disaster may also have an effect on how well the organisation prepares for future crises (Paton, Johnston, & Houghton, 1998). Alternatively, the difference in score between Surveys 2 and 3may be a reflection of the

respondents' states of mind at the time they were surveyed. Harter et al (2006) demonstrated that survey results can be affected by disaster.

Table 5-33: Survey 3 average sectoral resilience score using the Benchmark Resilience Tool (BRT)

Survey 3 average sectoral resilience score using the Benchmark Resilience Tool (BRT)			
	Average Sectoral Planning Factor Score	**Average Sectoral Adaptive Capacity Factor Score**	**Average Sectoral Resilience Score**
Building Suppliers	58%	67%	62%
Critical Infrastructure	78%	80%	79%
FMCG	68%	63%	66%
ICT	61%	76%	68%
Trucking	68%	74%	71%
Christchurch CBD	45%	63%	54%
Kaiapoi Town Centre	70%	70%	70%
Lyttelton Town Centre	61%	59%	60%
Entire Survey 3 Sample	64%	69%	66%

Figure 5-2 shows the difference in organisational resilience scores for each sector after Surveys 1, 2 and 3. The sectors with the largest difference in organisational resilience scores between Surveys 1 and 2 are critical infrastructure (30 percentage points), FMCG (26 percentage points), hospitality (31 percentage points) and trucking (20 percentage points). Self-report bias can explain one aspect of the trends for the organisational resilience scores obtained using the BRT. Some aspects of the organisational resilience scores will be further analysed in chapter 10 of this thesis. Another reason for the pattern of the organisational resilience scores is that they are associated with the chaotic time period in the immediate aftermath and short-term after disaster. It is also possible that organisational resilience levels were run-down between Surveys 1 and 2 and rebounded between Surveys 2 and 3. As highlighted in the future work section of this thesis, organisational resilience scores should also be captured in the medium- to long-term after the earthquakes in Canterbury to track recovery at different points in time.

Figure 5-2: Average sectoral organisational resilience scores for Survey 1, Survey 2 and Survey 3

5.6 Chapter summary

This chapter presented the results and discussion from the three surveys deployed during the course of the research. The surveys were deployed at different times, from two to eighteen months after the 4 September 2010, and asked about impacts to organisations from the Canterbury series of earthquakes. The results show the differing impacts to sectors after each survey period and show that the effects of the earthquakes lasted well beyond a few days after each event and can go on for extended periods. The results also showed some of the linkages present within and between different industry and geographic sectors and how these may affect recovery.

After all three surveys, organisations reported that their greatest challenge was the wellbeing of their staff. This was partly due to the prolonged earthquake sequence taking its toll on staff leading to fatigue and in some cases mistakes at work. The ongoing earthquakes also made it difficult to plan for and transition from response to early recovery. Other factors that contributed (positively or negatively) to organisational recovery after the earthquakes were:

- → the short or non-existent disruption times for utilities;
- → the localised damage which enabled relocation for organisations that were able;
- → the ability of organisations to work together;
- → neighbourhood effects (especially for the CBD and town centres);
- → skills shortage for some sectors;
- → increased workload for some sectors and decreased customer numbers for others;
- → location of customers (inside or outside the earthquake affected region);
- → uncertainty of supply, demand and a plan for recovery; and
- → adaptation to the dynamic conditions, e.g. by modifying delivery of goods and services.

These factors, from the surveys, that affected recovery are comparable to those identified in the contextual interviews in chapter 4 and those from the case studies in chapter 6.

The next chapter contains the results and analysis from case studies with selected organisations from each of the industry and geographic sectors in the study. Apart from standing on their own, the results from the case studies provide explanation for some of the data seen in this chapter with the quantitative portion of the research. The information in this and the next chapter will be used in tandem to determine which of three contributors; level of organisational or sectoral resilience, pre-earthquake conditions or direct and indirect earthquake effects; is the most significant to organisational recovery for organisations.

6 Case studies

This chapter introduces the case study organisations, presents the results of what issues the case study organisations faced after the earthquakes and compares how the different sectors were affected. The case study organisations are a subset of the entire sample group and had two representatives from each sector. Resource constraints (i.e. time, manpower, finance) meant that it was not possible to conduct in-depth case studies with the entire sample set. Criteria for selection of the case study organisations are explained in chapter 3.4. The case studies were designed to supplement and add to information collected via surveys and contextual interviews. This is because some qualitative, in-depth information is not as easy to obtain via survey questionnaires as it is through interviews with affected organisations. Using information from the case study organisations also allows for a more in depth comparison of how the sectors, represented by the case study organisations, were affected after the earthquakes: were they affected differently; were they affected similarly; and the reasons for this. It should be noted that the semi-structured interview technique was used for both the contextual interviews and case study interviews. However, apart from the different interviewees, the questions for the two segments were also different. Appendix A shows the informed interview consent form given to all interviewees and appendix H is the case study interview guide designed to ensure that the same baseline topics were covered with each interviewee. The baseline topics are for comparability between and within sectors.

As the case studies were done after Survey 1, the case studies were also used to corroborate some of the findings from the data analysis of Survey 1 and from the contextual interviews. Additionally, with the utilisation of case studies the researcher heard first hand from the organisations involved their description of events before, during and after the earthquakes and specifically how the organisations dealt with the different phases after the earthquakes. Understanding the recovery of the individual organisations enables the understanding of the recovery of the industry sector they belong to as well as what other agents they might affect or be affected by. The case study information, divided into the main-dimensions and sub-themes, is further used as one of the sources for the modelling of the system shown in chapter 8. The main dimensions and sub-themes are also used in the examination of system behaviour and for the

extraction from the system of the aids, hindrances and points of intervention in recovery (chapter 9).

The method used in the case study part of this study is outlined in section 3.4.4. The analysis was done using a modified version of Strauss and Corbin's (1998) grounded theory *coding paradigm* which outlines a logical way of gathering and ordering concepts or grouping of similar data. Grounded theory uses main dimensions, which can be divided further into sub-themes, to better organise data that falls within different groups.

This chapter starts with a description of the case study organisations and a synopsis of the important attributes of the case study set. This is followed by the results from analysis of the case study data, presented as the main dimensions and sub-themes, i.e. in what areas the sectors were affected. Results and analysis are interspersed with significant quotes from interviewees. The chapter ends with a comparison of the similarities or differences in how the sectors were affected.

6.1 Case study organisations

Presented here are details of each of the case study organisations in this research. In order to maintain confidentiality and anonymity, any identifying characteristics have not been given here. Each interviewee signed an interview consent form (see appendix A) that informed them of the confidential and anonymous fashion the information would be presented in. Each sector in the study had two representative case study organisations. Each organisation was asked to provide at least two interviewees, if possible from two different departments in the organisation. This was to give a broader overview of how the organisation was affected by the earthquakes. Some organisations provided only one interviewee while others provided two.

Additionally, each case study organisation was asked to provide details of the number of employees prior to the 22 February 2011 earthquake. Depending on the type of organisation (branch, subsidiary, standalone), some of the answers for employee numbers in this section are for the branch of the organisation the interviewee was answering on behalf of, while others are for the entire organisation.

Building suppliers

BS1: BS1 is a light manufacturing building supplier and has full time equivalent (FTE) staff of 80 in Christchurch. The organisation is half owned by an overseas company while the other half is publicly listed. BS1 has multiple branch organisations in New Zealand, with a head office in another city. The organisation has a functional role in head office specifically for organisational crisis management. Prior to the 4 September 2010 earthquake, BS1 had a documented emergency plan. They reported that for a manufacturing organisation, emergency planning which includes a strong emphasis on health and safety is crucial. BS1 provided specialist counselling services to staff and their families after the 22 February 2011 earthquake.

After the 22 February 2011 earthquake, BS1 in Christchurch got assistance from other branches that sent supplies such as water and food that were then provided to staff in Christchurch. The organisation reported that compared to other organisations or industries, BS1 was affected to a *minor* extent after the earthquakes. However, they also reported delayed re-opening after the 22 February 2011 quake due to difficulties securing geotechnical and structural engineering personnel to carry out the large number of inspections in the greater Christchurch area. They further reported that they used contacts in their industry to get the technical inspections done quicker. BS1 pointed to quick building inspections as crucial because of the closure of their factory and office complex, for geotechnical and structural assessment work, after all earthquakes over M_w 5.5.

BS1 worked with Civil Defence and with some of the critical infrastructure providers in the response and early recovery phase after the 22 February 2011 earthquake. They provided supplies for search and rescue as well as materials used to repair breaks in water and wastewater pipes. Due to high demand, the organisation ran out of the supplies for the pipes and had to look overseas for more stock.

Post-earthquakes, BS1 was affected by the uncertainty in the construction industry. They reported that this made it difficult to make long term strategic plans regarding the rebuild. BS1 carried out a review of their emergency response and identified some areas to be worked on. One of the areas for improvement was evacuation: how to ensure that people have left the site and to verify their wellbeing in a timely fashion thereafter.

BS2: BS2 has an FTE of 44 and is a wholly owned subsidiary of a larger New Zealand organisation. They are a wholesale building supplier and reported being affected by the global financial crisis. BS2 reported being relatively unaffected by either the 4 September 2010 or 22 February 2011 earthquake because of their location in the north-west of Christchurch. The organisation also reported the possibility of getting assistance from their owner if the need arose. BS2 has branches in other parts of New Zealand's South Island. They detailed that if the Christchurch plant were shut down, the combined capacity of the other branches could make up for the shortfall in production. BS2 reported being affected by the uncertainty around when the major part of the rebuild would start. The organisation narrated that they were able to supply after earthquakes but there was little demand for their product.

BS2 used in-house civil engineers to check their premises for damage and subsequently to check all employee houses. They then deployed these engineers to help with geotechnical and structural assessments for the greater Christchurch area. BS2 organised counselling for their staff on the organisation's premises. This counselling was extended to family of staff as well.

Prior to 4 September 2010, the organisation did not place much emphasis on emergency planning even though they had regular fire drills. The organisation reported that after the 4 September 2010 earthquake, they recognised that their emergency planning needed improvement and were in the process of reviewing these plans. Also using the earthquakes as an opportunity, BS2 were planning to outsource their logistics function. They cited increased vehicle maintenance costs and the need to concentrate on their core business as reasons for this. However, of concern to the organisation was the possible shortage of skilled labour (especially heavy vehicle truck drivers) which would affect the construction industry when the rebuild got underway. In readiness for the rebuild the organisation budgeted for staff hire and training and redesigned some of their products to align with revisions in the building code.

Critical infrastructure

CI1: CI1 is a transport provider and has just over 250 FTE staff. They are owned by a larger organisation but have an independent commercial board of directors. Their main office is in the Christchurch CBD. The organisation reported no previous crisis experience. Prior to 4 September 2010, the organisation had a business continuity plan that they reported did not specifically include earthquakes but considered hazards such as floods and power outages.

The organisation reported being more affected by the 22 February 2011 earthquake. Earthquake damage to one of their workshops led to the extension of another of their buildings for use as a workshop. CI1 detailed that their equipment could operate after 22 February 2011 but that they were affected by the condition of the roads. They also pointed to increased maintenance costs after earthquakes because of damage to roads. The organisation was further affected by congestion on the roads due to reduced road capacity after the earthquakes. Additionally, CI1 narrated that customers reduced by approximately 40% post-earthquakes because of the relocation of organisations and people to different parts of the city. Other effects were as the result of damage and closure to Lyttelton Port. As part of managing the crisis after the earthquakes, CI1 put on special services to cater for temporary route changes that had taken place.

CI1 recognised that in the longer-term recovery period, the organisation would be affected by population shifts and land use planning decisions. These shifts in population would also require modification of existing services or the addition of new services. CI1 reported that one of the aids in recovery for them was having a mature workforce that could handle crisis. Some considerations in response and early recovery included making sure that no staff were made redundant.

CI2: CI2 is a government department with a FTE staff of 26. They reported that in considering their mandate, they were not very affected by the earthquakes. They were however affected in the 22 February 2011 earthquake because their CBD offices were damaged. CI2 was affected by restricted access to their CBD office as this meant that they could not access some organisational information and specialised equipment. The organisation had both emergency plans and business continuity plans. They reported that in the lifetime of the organisation, there was some prior crisis experience but that these crises had been caused by other hazards such as floods.

CI2 worked closely with Civil Defence in response and early recovery. They detailed that some of their work with Civil Defence involved the modification of by-laws to suit the disaster environment. They also brought experts in from their Auckland office to help manage the response. The organisation reported that some of their repair work was affected by the ongoing

earthquakes. In addition, the extra work done after the earthquakes increased the department's costs.

Post-earthquakes, CI2 related how they lost some of their qualified staff to private contractors in the same line of work. They reported that they recognised that they could not compete to retain staff based on salary as government roles have such details pre-defined. Instead, they wanted to work on the environment inside the organisation as a way of retaining people. The organisation reported that their future plans would also be affected by decisions on land use.

The organisation managed to relocate to new premises after the 22 February 2011 earthquake. They also conducted a formal review of their actions in the response phase. Some areas for improvement included the management of information and communication as well as succession planning and relief for people in the response phase of a crisis. Pre-disaster networking also emerged as important: particularly the awareness that it is people in organisations who connect and not necessarily the organisation as an entity.

Fast Moving Consumer Goods (FMCG)

FMCG1: FMCG1 is an independent chain of service stations and associated retail outlets that are part of a franchise. They are performance managed by the franchise and do not have to follow franchise regulations to the letter. They have a FTE staff of 58 in eight locations in the greater Christchurch area. As a consequence of the industry sector they belong to, health and safety are taken very seriously. Prior to the 4 September 2010 earthquake, FMCG1 conducted monthly trial evacuations and had a designated safety officer at each of their locations. The organisation reported having very devolved decision making for each site and no prior experience of a large crisis.

FMCG1 reported not having business interruption insurance because they did not think all eight locations would be affected at the same time. The organisation was affected in different ways by the 4 September 2010 and 22 February 2011 earthquakes. For 4 September 2010, they narrate that it was more staff and their families who were affected and operations were restarted quickly. After the 22 February 2011 earthquake, both people and the physical infrastructure of the organisation were affected. Operations did not restart as quickly as in 4 September 2010, in part because of a shortage of geotechnical skills to carry out inspections.

FMCG1 provided staff with supermarket vouchers after both the 4 September 2010 and 22 February 2011 earthquakes. This was in addition to the offer of counselling services. In reviewing their actions in the response and early recovery phase, FMCG1 modified their internal methods of communication. They upgraded their physical communication system as well as their data management system and also instituted different measures of communication between people in the organisation in the event of a crisis. After the 22 February 2011 earthquake, EFTPOS (electronic point of sale) terminals did not work in some parts of the greater Christchurch area. As a result, FMCG1 gave away product to customers for free until EFTPOS service was restored or until goods ran out.

FMCG2: FMCG2 is wholly owned by a multinational corporation. It has multiple branches in New Zealand and FTE staff of 53. The New Zealand part of its business is the supply of goods; manufacturing of these goods is done in Australia and parts of Asia. The organisation reported not knowing of any documented organisational emergency plan. However, they did have plans for first aid and for security threats. The interviewee also reported having no knowledge of organisational business continuity plans. It appears this may be because of their being a branch organisation and the expectation that head office looked after such matters. FMCG2 reported having no prior disaster experience.

After the 4 September 2010 earthquake, FMCG2 was affected by warehouse damage at two levels. The first was damage to their own (third party run) warehouse as well as stock, and the second was damage to customer warehouses and stock. Damage to customer warehouses meant that FMCG2 could not deliver supplies to these warehouses. Damage to customer stock led to an increase in demand for new supplies. Collaboration with the customer led to the delivery of supplies directly to retail outlets. This required re-packaging of stock in quantities suitable for smaller deliveries. Other collaboration with customers was in the form of identification of goods needed in the response phase. They agreed to scale down on low volume sellers in order to bring in more of needed goods.

FMCG2 reported that in the response phase, they were aware of which of their competitors could not manage to meet demand. However, they did not take advantage of this in part because this segment of the sector has only a few players and they would need to work with each other

after the earthquakes. FMCG2 helped in the response effort by donating goods to the Red Cross. FMCG2 reported that they had not done a formal review of their response to the earthquakes but had spoken about it informally.

Hospitality (bars, cafes and restaurants)

H1: H1 is a franchise that was based in the CBD and had a FTE staff of 6.5. The organisation was located in the CBD because of the large number of employers based there as well as other foot traffic. H1 reported not having emergency or crisis plans prior to the 22 February 2011 earthquake and no prior crisis experience. However, they did have plans for power outages. They reported that these plans were not helpful after the earthquakes. H1 did not have computer data back-ups of key information. However, they reported that their head office had a record of all daily transactions which they could use for tax purposes.

After the 4 September 2010 earthquake, H1 experienced a 20% drop in revenue because some employers evacuated from the CBD area. After the 22 February 2011 earthquake, the organisation lost their premises. H1 made arrangements for some employees to work in other franchises locations on the proviso that they would return when the organisation re-opened. The interviewee felt that, in general, there was too much bureaucracy in getting hospitality organisations relocated and re-opened. They felt that the advice on insurance and legal issues from the franchise owner was helpful. However, H1 reported that they did not think advice from the industry association was helpful.

At the time of the interview (14 November 2011) H1 was looking for alternative premises to relocate to outside the CBD area. They were however affected by the inability to access their premises and equipment which were within the CBD cordon. The lack of information and inconsistent information around building access was a source of frustration for H1. Access to the premises was also needed so they could document damage for insurance purposes as part of the relocation process. By the time the organisation accessed their premises, they had been looted and vandalised. The organisation had good insurance cover but was affected by the delay in settlement of their claim.

H2: In the 4 to 5 years leading up to the 4 September 2010 earthquake, H2 had bought out of a franchise and gone through a period of rebranding. The rebranding involved the development of

a niche market in the hospitality sector. The organisation had a FTE staff of 6. The organisation had documented plans and drills for fire but no other emergency plans. They also reported having no prior crisis experience.

After the 22 February 2011 earthquake, H2's premises were green-tagged (safe to enter) but in the fall zone of other buildings in the CBD. H2 reported being affected by lack of access to their premises as they had difficulties getting permission to enter the CBD cordon. At the time of interview (15 November 2011), all of H2's employees left H2 and were working in other organisations. Prior to this, the organisation accessed the Earthquake Support Subsidy (ESS) provided by Central Government.

H2 was willing to relocate but could not as their insurance company preferred to know the long-term plan for the CBD before signing off on relocation. This was also one of the reasons given by the insurance company in delaying settlement of their claim in full. However, H2's reoccupation of their old premises was also dependent on decisions by the building owner. Additionally, H2 detailed that going back to the CBD was equally dependent on the overall plan for the CBD rebuild. This is because the organisation was formerly reliant on custom from the now relocated employees of large employers, as well as foot traffic into the area.

Considering the length of time the organisation was closed, health and safety laws decree that the equipment should be disposed of. H2 reported that in case of their agreeing to an insurance settlement, it would be based on the present value of equipment. However, if the organisation re-opened or relocated, the insurance company would have to pay for new equipment. After the 22 February 2011 earthquake, H2 worked with some of the other business owners from the same vicinity of the CBD. This was for the purposes of information sharing and support. H2's owner also kept in regular contact with the organisation's former employees.

Information and Communication Technology (ICT)

ICT1: ICT1 is a manufacturing ICT organisation with FTE staff of 135. They are a subsidiary of a multinational corporation. The organisation reported that prior to the earthquakes, they had been affected by the shift of manufacturing to places with lower labour rates, e.g. China. ICT1 had no previous crisis experience but had very detailed emergency, crisis and business continuity

plans formulated to enable response to different hazards. The organisation reported that the plans were of value in that people knew what to do in the immediate aftermath of the earthquakes. However, the interviewee spoke of gaps in the plan in relation to employees accessing their personal belongings such as mobile phones and keys, which could not be taken onto the shop floor, and also in procedures to safely re-enter the building. ICT1 has a focus on staff health and safety.

The 22 February 2011 earthquake caused considerable damage to ICT1's premises and equipment. However, the organisation was operating again approximately two to three weeks after the earthquake. They reported that they could have opened sooner had they been able to have their premises inspected quicker by geotechnical personnel. Despite this delay, ICT1 managed to supply spare parts to critical infrastructure organisations in the response phase. The organisation narrated running out of spare parts that are usually not replaced frequently during business-as-usual. ICT1 reported that they were also very aware of when and how their other customers (especially those outside Christchurch) would be affected by disruption to the supply web. This timeline was affected by ICT1 not knowing what condition their manufacturing equipment was in as they could not access their premises. The organisation reported that the equipment they use is not available in New Zealand and has a three month lead time when ordered. In order to meet demand, ICT1 prioritised customers in their supply chain and worked overtime to catch up on lost production. They also reported that they met with their non-Christchurch customers to reassure them of continued ability to supply. ICT1 had mutual aid agreements for location sharing. However, any alternative location was only helpful to a point as the manufacturing equipment was on ICT1's main premises.

ICT1 reported that the damage to their premises, worth hundreds of thousands of dollars, had to be paid for from local profits. This was because the excess on their organisation's corporate insurance policy was larger than the damage to the Christchurch plant. However, ICT1 could not make major repairs to their buildings as the area they were in had liquefiable soils. They therefore had to wait for more extensive geotechnical inspections before knowing if they could repair the building or had to move to new premises altogether. ICT1 detailed that all pre-earthquake expansion plans had been put on hold as the funding for these was directed to earthquake repairs. The organisation applied to the New Zealand Ministry of Science and Innovation (MSI) for a recovery grant to help pay for the resumption of expansion plans.

ICT1 set up an earthquake fund for staff. They also engaged counsellors to work from the organisation's premises readily available for staff. ICT1 conducted an official review of their response after both the 4 September 2010 and 22 February 2011 earthquakes. The organisation recognised that they had good evacuation plans but no re-entry procedures. Re-entry procedures and Tsunami evacuation plans were added to the reviewed crisis plans. Other measures included all employees, not just those on the shop floor, signing in and signing out as a way of keeping track of who was on site. Further, staff on the shop floor were allowed to have their keys and mobile phones with them, which pre-earthquakes were kept in lockers in a different part of the premises. This was to avoid staff going back into a potentially unsafe building to retrieve these items or delaying getting out because they needed to look for them. ICT1 also reported that other actions from the review centred on better communication in crisis and better succession planning.

ICT2: ICT2 provides professional, specialised ICT services to other sectors such as health. They are a wholly owned, privately held New Zealand company with an Australian subsidiary. Their main office is in Christchurch with a small branch in Auckland and they have FTE staff of 31.5. Prior to 22 February 2011, ICT2 was located in the CBD. In their field, ICT2 have a large segment of the New Zealand market and approximately 30% of the Australian market.

ICT2 reported having a combined emergency and business continuity plan that was incomplete and had been in development (slowly) for a long time prior to the 4 September 2010 earthquake. The organisation reported that this plan fell far short of what was needed especially for an event such as the 22 February 2011 earthquake. The organisation had a skills shortage prior to the earthquakes and this was magnified after. In fact, ICT2 reported that experienced staff voluntarily left the organisation because of the earthquakes.

After the 22 February 2011 earthquake ICT2's premises were red tagged. The organisation reported having trouble finding suitable accommodation to relocate to until August 2011. While looking for accommodation, some staff were sent to work from the Australian office. Other staff worked from home which they said affected their family relationships. They reported that working from home for such long periods blurred the boundaries between work and home. However, added to the shared experience of the earthquakes, working from the non-office

environment of a co-worker's home brought people even closer together and enhanced team bonding. Team bonding was also reinforced because team members had the common goal of wanting their organisation to recover.

ICT2 reported that they had problems accessing their premises after both the 4 September 2010 and 22 February 2011 earthquakes. This was because they were not allowed to enter the cordoned area to retrieve business critical material and to restart equipment. After the 4 September 2010 earthquake, ICT2 faced the issue of not being able to access critical records stored on their premises. Between the 4 September 2010 and 22 February 2011 events, ICT2 augmented their backup practices and also engaged another organisation to look after their information technology (IT) system backup. However, after 22 February 2011, the organisation looking after ICT2's IT backup sustained damage to their premises and equipment. This meant that for a time after the 22 February 2011 earthquake, ICT2 had problems retrieving some organisational records. Additionally, as a result of building damage after the 22 February 2011 earthquake, ICT2 lost some organisational information in paper form. As a short-term measure after 22 February 2011, ICT2 housed some of their technical equipment in seismically retrofitted customer premises.

ICT2 detailed that their customers paying bills before the due date was a help in recovery. Another aspect helpful in response and early recovery was that senior management were from Christchurch and had also been affected by the earthquake. The interviewee reported that staff felt this helped with some of the decision making. The Earthquake Support Subsidy (ESS) was also a major boost. Additionally, ICT2 made the decision that even in the absence of complete records, all staff would still be paid based on the last pre-earthquake payroll instructions to the bank. ICT2 also ensured that all staff knew that they had access to counsellors. Employees were given extra leave days, in addition to the statutory leave days, in order to sort out earthquake issues.

ICT2 reported that their organisational expansion plans were put on hold while they assessed their situation after the earthquakes. In a review of the organisation's emergency plan, ICT2 identified that the staff communication plan for the response phase needed improvements. As well, the organisation recognised that there had to be a trade-off between what preparedness planning they could engage in relative to the size of the organisation.

Trucking

T1: T1 is part of an Australian multinational corporation and has FTE staff of 2500 in New Zealand and 500 in Christchurch. The organisation's head office is in Auckland. T1 reported that they are in a very competitive market segment. The organisation also reported that it is the largest in its subsector in NZ and that they have a diverse business portfolio. T1 reported not having any documented crisis plans but did have an undocumented organisational response mechanism for crisis because of prior experience with other hazards such as floods and fires. The organisation reported that their senior management team was very good at dealing with crisis.

After the 22 February 2011 earthquake, T1 worked closely with Civil Defence who required their services. They also coordinated, for the trucking sector, sectoral activity in the aftermath of both the 4 September 2010 and 22 February 2011 earthquakes. They noted that this had to be done diplomatically to maintain good relations post-earthquake. As a result of an increase in demand for their services, T1 brought in resources from other New Zealand branches. This was in addition to dealing with their business-as-usual customers, some of whom had been adversely affected by the 22 February 2011 earthquake. T1 reported that they prioritised customer work depending on the importance of the customer.

The organisation mobilised resources to assist staff, especially after the 22 February 2011 earthquake. This assistance was in the form of a welfare fund for staff that qualified as well as shower and laundry facilities. The organisation also organised a team to visit each staff member's house to assess recovery needs. Part of helping staff involved monitoring staff workload after the increased demand for organisational services led to staff working longer hours.

T1 was affected by damage to roads and reported that they had to carry out more frequent maintenance on their fleet. Other effects included increased traffic which led to congestion and more time on the road. The organisation reported that the land reclamation in Lyttelton was a help in the response phase as this meant they could dispose of demolition waste quicker and not stockpile it on demolition sites which would have slowed down the demolition work. However, in working with Civil Defence, T1 feel that the transition between the response and recovery

phases was not done well. This is because the information for demolition and associated work was unclear or non-existent during the transition phase.

T1 saw the need to expand some of their operations after the 22 February 2011 earthquake in order to meet demand and provide better service. This increased demand and scaling up of services resulted in higher revenues for the organisation. T1 conducted a semi-formal review of the response actions and disseminated this information to all their New Zealand offices.

T2: T2 is a public-private-partnership (PPP). They provide an essential service and have FTE staff of 45. The organisation had emergency plans prior to the 4 September 2010 earthquake. They also had a business-as-usual independent telecommunications system which was helpful for communication in the response phase.

After the 4 September 2010 earthquake, T2's customers were severely affected which then affected the organisation. After the 22 February 2011 earthquake, due to industry sector or location, T2's organisation's customers were less severely affected. However demand for T2's services increased dramatically. They were assisted in meeting this increased demand by staff from their other New Zealand offices as well as from contractors. Even then, staff still worked long hours to meet demand. The organisation set up a welfare scheme for staff which included an earthquake fund that staff could apply for. T2 also organised food, water, shower and laundry facilities for staff and their families.

T2 reported that until September/October 2011, they were affected by the erratic nature of demolition activity, especially from the CBD. This affected some of the organisation's forward planning. T2 carried out a review of its response and found that prior good relations with other organisations were a help in response and early recovery. The organisation also reported that they were in the process of setting up a shared resource database with other sister companies. This is so that all branches would be aware what resources were available to them in case of emergency.

Christchurch CBD

CCBD1: CCBD1 is a New Zealand owned company with branches around the country. Its headquarters and main distribution centre are in Christchurch. Prior to 4 September 2010, the

organisation had no documented crisis plans and no prior crisis experience. The stock in CCBD1's Christchurch stores was uninsured. This decision was reached after the organisation decided it was better to insure stock in Wellington branches as that was a higher seismic risk than Christchurch. CCBD1 reported being more affected by the 22 February 2011 earthquake. Of the three branches in Christchurch, the premises for two of them were severely damaged in the earthquake. With the closure of two stores in Christchurch, CCBD1 made the decision to cancel stock orders for March and reported that this affected their suppliers negatively. As part of the response, one of the management team based in Auckland was brought in to assist staff in Christchurch.

CCBD1 reported that they had difficulty accessing both of their CBD premises as they were not allowed to enter the cordoned off area. Access to the stores was required to verify the conditions of the stores and to retrieve millions of dollars' worth of stock. The organisation also detailed that they got conflicting information for entry procedures to the CBD Red Zone.

CCBD1's third Christchurch branch had become operational approximately 1 month prior to the 22 February 2011 earthquake. Staff from the two branches not in operation were transferred to the third branch to avoid redundancies. The organisation reported that the Central Government Earthquake Support Subsidy (ESS) was one of the contributors that enabled the retention of all staff. After the 22 February 2011 earthquake, one of the top recovery priorities for CCBD1 was business interruption for their other branches as the main distribution centre was in Christchurch. However, in the first few days after the 22 February 2011 earthquake, their couriers did not travel outside the Christchurch region which made it difficult to ship stock to non-Christchurch branches. The organisation's other priorities included the provision of equipment to earthquake search and rescue teams.

CCBD1 expressed that they were interested in going back to the CBD but did not know when as there was uncertainty surrounding when and how the CBD would be rebuilt. CCBD1 also indicated that the lack of information on the selection process for the organisations involved in the CBD's Re:Start Project made it difficult to know what the rebuild plan for the CBD was. This was a factor in the extension of the lease agreement on their third, newly opened, Christchurch branch. Another factor was that their customers had got used to visiting the new

store and there were plenty of support and professional services that had also set up in the area. CCBD1 pointed out that they had been in talks with their competitors to find out if these other organisations were willing to go back to the CBD. The collaboration with competitors came about in part because they have a shared customer base which benefits all parties when they are in the same vicinity.

CCBD1 added that the 4 September 2010 earthquake was a wake-up call for them to review their emergency plans and how they delivered goods and services. They initiated a formal review of these issues post-September 2010. This review was ongoing at the time of the 22 February 2011 earthquake. After 22 February 2011, the organisation also started trading online and was able to reach a wider customer base.

When asked, CCBD1 did not provide employee numbers. No reason was given.

CCBD2: CCBD2 is a New Zealand owned organisation with FTE staff of 18 in the Christchurch area. They provide specialised equipment and rely predominantly on customer discretionary spending. CCBD2 had no documented emergency plans and no crisis experience before 4 September 2010. Prior to the 4 September 2010 earthquake, CCBD2 and all their major competitors were in close proximity to each other in the CBD.

After the 4 September 2010 earthquake, CCBD2's store was in the fall zone of another building; this led to the closure of the store for a period of time. After the 22 February 2011 earthquake the organisation's premises were badly damaged and closed. The organisation relocated after overcoming the challenge of finding new premises they could lease short-term (to 2014). The reason for the short-term lease was because they still had a lease on their damaged Christchurch store. The organisation expressed that the uncertainty surrounding the rebuild of the CBD made it difficult to negotiate out of their lease. Also, CCBD2 felt that it would have been easier to break their lease and to get their insurance settlement if their premises had fallen completely and if the stock had been damaged. Because the building was yellow-tagged (restricted use and access), the insurance company communicated that they had to wait for the building inspector's report and retrieve stock.

In their new location, CCBD2 used advertising to inform the public of their new premises and reported that their being a destination business was a help in getting their customers back. In the

aftermath of the 22 February 2011 earthquake, they travelled to customers' premises as a way of delivering goods and services. CCBD2 was affected by the reduced arts and entertainment locations in Christchurch. This is because both the arts and entertainment venues and the customers who frequented them were some of CCBD2's main customers. CCBD2 were also affected by reduced customer discretionary spending.

CCBD2 felt that there was a lack of support from their corporate office but that this allowed them to make their own decisions. In addition, the staff in the Christchurch store said they felt underappreciated after all the effort to get new premises operational. At the time of the interview (31 January 2012), the manager for the Christchurch store said he was planning a formal review of the organisation's actions in response. However, this had not taken place as a large percentage of time was taken up getting the new store up and running. This was crucial to keep staff employed.

Kaiapoi Town Centre

KTC1: The organisation provides specialised, non-substitutable services and is an independent organisation. However, KTC1 belongs to a family of similar independent organisations based in different parts of New Zealand. In the history of the organisation, interviewees reported that the only other large crisis the organisation may have faced was in the 1940s. However, none of the current staff had been there for that crisis. KTC1 reported having emergency for plans for fire and pandemics but did not have documented business continuity plans.

KTC1 was affected differently by the 4 September 2010 and 22 February 2011 earthquakes. The 4 September 2010 earthquake caused physical damage to the building and assets of their Kaiapoi branch. The 22 February 2011 earthquake affected them by way of an increased demand for their services. After the 22 February 2011 earthquake, in addition to dealing with business-as-usual KTC1 worked closely with Civil Defence in response and early recovery. After the 22 February 2011 earthquake KTC1 reported collaborating with other Christchurch organisations from their sector. They also had offers of assistance from their sister organisations outside Christchurch and reported that it was good to know that the assistance was available, even if they did not use it.

In reviewing their actions in response, KTC1 expressed that the organisation came to the conclusion that they did not need to change much of their existing arrangements. For longer-term recovery however, KTC1 detailed that they would be affected by population and land use decision plans.

When asked, KTC1 did not provide information on employee numbers.

KTC2: KTC2 is operated by its owner who occasionally works with a partner. Apart from the owner, KTC2 has no other employees. The organisation reported not doing well financially prior to the 4 September 2010 earthquake because of the global financial crisis (GFC). This is because one of their primary clients, the agricultural sector in Canterbury, was affected by the GFC. The owner reported that the organisation had inadequate insurance cover because they could not afford the insurance premiums and that the organisation did not have prior crisis plans. KTC2 was located in Kaiapoi because of more affordable commercial accommodation while still being in close proximity to Christchurch.

After the 4 September 2010 earthquake the organisations offices were damaged but usable. After the 22 February 2011 earthquake, the organisation's offices were severely damaged and closed. The organisation was further affected by the shortage in geotechnical personnel as they had to wait for technical inspections before they could access their premises to retrieve specialist equipment and organisational records. The organisation had back-ups of its electronic but not paper records. KTC2 eventually relocated but cited that this was a major cost.

KTC2 were indirectly affected by insurance delays as their customers who were waiting for insurance claim settlements could not pay them. The organisation reported that they were planning to expand their operations prior to the 4 September 2010 earthquake but that these plans had been put on hold. KTC2 applied to New Zealand's Ministry of Social Development (MSD) for a monetary grant to help with cash flow.

For longer-term recovery, KTC1 reported being aware of the need to network more as a way of hearing about upcoming work. This was especially important considering the small size of the organisation. However, one of the post-earthquake options being considered by the organisation was to close and move out of the Canterbury region.

Lyttelton Town Centre

LTC1: LTC1 is owner operated, has no staff apart from the owner and deals in semi-luxury goods. The organisation was located in Lyttelton because the owner has strong ties to the town. Prior to the 22 February 2011 earthquake, LTC1 had no documented emergency or crisis plans. However, the organisation reported that they had a fire extinguisher and a first aid kit.

The organisation was more affected after the 22 February 2011 earthquake by minor damage to premises and by being in the fall zone of a building to be demolished. LTC1 had a good insurance policy but did not lodge an insurance claim after the 22 February 2011 earthquake as the excess was more than the damage sustained. LTC1 detailed that the quick building demolition in Lyttelton was helpful for the re-opening of the organisation. However, prior to re-opening, LTC1 had a stall at the Lyttelton Farmers' Market mainly to remind customers that the organisation would re-open. LTC1 reported that having a stall at the market also enabled the organisation to assess the post-earthquake need for their products as they were reliant on customer discretionary spending. On re-opening, LTC1 was affected by the dust from the ongoing demolition of nearby buildings and had to clean more regularly. The organisation reported that this took up valuable time. LTC1 used the Earthquake Support Subsidy (ESS) as part of recovery finance. Organisational expansion plans were put on hold after the earthquakes.

In the period of closure after the 22 February 2011 earthquake, LTC1 maintained contact with their regular suppliers to inform them of progress on re-opening. LTC1 reported paying some of their suppliers in advance in order to help with their cash flow and recovery. LTC1 also reached the decision to use more Christchurch suppliers after the earthquake as way of helping them to recover. LTC1 also offered space on their premises to another organisation from Lyttelton Town Centre whose building had been demolished: no rent was asked for.

LTC2: LTC2 was run by two partners prior to the 22 February 2011 earthquake. The organisation was a partnership with not much formal documentation. One partner had insurance while the other did not. They offered specialist services heavily reliant on customer discretionary spending both in New Zealand and overseas. LTC2 had no crisis plans and no prior crisis experience. The organisation was based in Lyttelton because both partners thought the town ideal for their type of work.

LTC2's premises suffered substantial damage after the 22 February 2011 earthquake and had to be demolished. Prior to the demolition, the organisation faced delays and uncertainty on whether they could access their premises and retrieve expensive, specialist equipment not available in New Zealand. The delay was due to the shortage of structural engineering personnel to conduct an inspection of the building. LTC2 reported that they decided to get around this by using connections another tenant in the building had with people trained in search and rescue. Search and rescue personnel escorted them on to the premises, however due to time constraints they were unable to bring out all their equipment.

Without work space, the partners in LTC2 each worked from their homes. They reported that they missed the creative environment they had when they worked together. The organisation also reported being affected by reduced arts and entertainment locations in Christchurch, to which they have strong links. As a consequence of reduced sales, LTC2 faced a cash flow problem in the months after the 22 February 2011 earthquake. They applied for a monetary grant made available to organisations in their line of work. The information about the grants was got from being in touch with similar organisations that had come together to form an online self-help group.

6.2 Synopsis of the case studies

All except one of the organisations interviewed reported doing well financially prior to the 4 September 2010 earthquake. The organisation facing financial difficulties reported that the global financial crisis was the primary cause of its financial underperformance. All the organisations had insurance except KTC2 which was under-insured and LTC2 which was half-insured. Incidentally the organisation that reported not doing well financially was the same one that reported the instance of under-insurance.

There are two main reasons that account for how the case study organisations were affected by the earthquakes. The first is that sectoral attributes such as the type of goods and services delivered played a part in what some of the effects to organisations were. For instance, trucking organisations reported a rise in demand for their services while some hospitality organisations reported a decrease in customer discretionary spending. The second main reason for differential effects was the organisation's location at the time of the earthquakes. Some parts of the greater Christchurch area were more affected by the 4 September 2010 earthquake (e.g. Kaiapoi) than by

the 22 February 2011 earthquake (e.g. Lyttelton, Christchurch CBD and Christchurch's eastern suburbs.) Organisations described the 4 September 2010 earthquake as having partially prepared them for the subsequent 22 February 2011 earthquake especially, the response and early recovery phases.

To complement the mainly qualitative information provided by the case study organisations in interviews, Table 6-1 is a snapshot of fundamental information from surveys 1, 2 and 3 that encapsulates the main dimensions and sub-themes that follow. This information is also used in chapter 10 in the discussion on organisational disaster resilience.

*Table 6-1: Relevant survey data to complement synopsis of case study organisations**

	Survey 1			Survey 2						Survey 3**			
Case study code	**Organisational resilience score**	**Customer base changes**	**ODoE (out of 100)**	**Organisational resilience score**	**Recovery Rate Coefficient (RRC) (from -2 to +2)**	**ODoE (out of 100)**	**Closure impact factor (out of 15)**	**FTE redundancy**	**FTE hire**	**Organisational resilience score**	**Recovery Rate Coefficient (RRC) (from -3 to +3)**	**Operational status**	**Self-report organisational performance**
BS1	74%	Decreased moderately	10	40%	-2	47	7	No	No	Did not take part	Did not take part	Did not take part	Did not take part
BS2	65%	No change	5	45%	-2	5	0	No	Yes	62%	-3	Open-Trading	Slightly Better
CI1	84%	Decreased moderately	12	42%	0	55	0	No	No	78%	-1	Open-Trading	Slightly Worse
CI2	72%	No change	29	44%	0	81	3	No	No	Did not take part	Did not take part	Did not take part	Did not take part
FMCG1	61%	Did not answer	Did not answer	37%	1	72	6	No	Yes	79%	2	Open-Trading	Slightly Better
FMCG2	80%	No change	13	29%	0	58	4	No	No	Did not take part	Did not take part	Did not take part	Did not take part
H1	67%	Decreased substantially	Did not answer	33%	2	100	10	No	No	Did not take part	Did not take part	Did not take part	Did not take part
H2	67%	Decreased substantially	24	27%	-2	94	3	Yes	No	Did not take part	Did not take part	Did not take part	Did not take part
ICT1	72%	No change	20	47%	0	50	6	No	No	Did not take part	Did not take part	Did not take part	Did not take part
ICT2	65%	No change	26	35%	0	81	10	No	Yes	65%	0	Open-Trading	Slightly Better
T1	93%	Decreased moderately	14	33%	2	48	0	No	Yes	82%	3	Open-Trading	Slightly Better
T2	79%	Increased substantially	4	43%	2	54	0	No	Yes	Did not take part	Did not take part	Did not take part	Did not take part
CCBD1	67%	Decreased substantially	21	36%	-2	74	5	No	No	67%	-1	Intend to re-open	Slightly Better

	Survey 1			Survey 2						Survey 3**			
Case study code	**Organisational resilience score**	**Customer base changes**	**ODoE (out of 100)**	**Organisational resilience score**	**Recovery Rate Coefficient (RRC) (from -2 to +2)**	**ODoE (out of 100)**	**Closure impact factor (out of 15)**	**FTE redundancy**	**FTE hire**	**Organisational resilience score**	**Recovery Rate Coefficient (RRC) (from -3 to +3)**	**Operational status**	**Self-report organisational performance**
CCBD2	100%	Decreased substantially	36	33%	-2	83	11	No	No	31%	-3	Open-Trading	Slightly Worse
KTC1	76%	Did not answer	Did not answer	35%	0	45	3	No	No	Did not take part	Did not take part	Did not take part	Did not take part
KTC2	68%	No change	36	50%	-2	35	7	No	No	61%	-3	Open-Trading	Slightly Worse
LTC1	Did not take part	Did not take part	Did not take part	42%	-2	73	1	No	No	21%	-2	Intend to re-open	Slightly Better
LTC2	Did not take part	Did not take part	Did not take part	24%	-1	97	3	No	No	Did not take part	Did not take part	Did not take part	Did not take part

**The organisational degree of effect (ODoE) was presented in section 5.1. The recovery rate coefficient (RRC) and the closure impact factor are explained in detail in sections 7.3 and 7.4.5.*

***The case studies were conducted in between Surveys 2 and 3; see research timeline in section 3.4.2.*

6.3 Main dimensions and sub-themes emergent after analysis of case study data

The results in this chapter are documented under the headings of main dimensions and their sub-themes. In other words, the main dimensions and sub-themes are the issues that the case study organisations faced after the earthquakes. The main dimensions and sub-themes were arrived at using the grounded theory approach: they were not pre-determined. They emerged from analysis of the case study data and using open coding. Open coding allows for the grouping of similar ideas without a pre-determined heading assigned. The analysis of the case study data was done after each case study. Coding enabled the identification and conceptualisation of the large body of case study data and led to these main themes and sub-dimensions. The coding paradigm corresponds with the different parts defined in the case study interview guide and with the systems thinking approach (see chapter 3.5.4).

The headings for the main dimensions and sub-themes are captured briefly in Table 6-2 and then explained in detail, as sub-chapters 6.4 to 6.12, in the sections that follow. The captions of the main dimensions and sub-themes were arrived at by using information that best encapsulated the information in the main theme or sub-theme and sometimes from words used by the interviewees. The main-dimensions and sub themes illustrate the ways in which the sectors were affected. Even as the main dimensions and sub-themes are the issues that arose for the sector, different sectors were sometimes affected differently for the same sub-theme.

The main dimension organisational actions in the response phase has no sub-themes. It emerged as a result of the description of actions carried out by the case study organisations in the response phase after the earthquakes. Some of these actions included verifying staff wellbeing, checking buildings and machinery and confirming resumption of service to customers. Another main dimension that emerged was wellbeing and its sub-themes of staff, family and community wellbeing. All organisations interviewed spoke of how these three strands of wellbeing were necessary for organisational recovery. A third main dimension was leadership where some of its sub-themes are sectoral leadership, recognising and grasping opportunity, communication and leadership of the overall recovery effort. Case study organisations pointed to good, competent leadership as one of the important aspects of recovery. These and all the other main dimensions and sub-themes are discussed in detail in chapters 6.4 to 6.12.

Importantly, the main dimensions are presented separately but are not independent of each other. They are connected and relate to the overall theme of the thesis: that of the dynamics of organisational and sectoral recovery after the Canterbury earthquakes of 2010 and 2011. From chapter 2, the definition of recovery used in this thesis is *when an organisation or sector can function and sustain itself (continually) in its new post-disaster environment.*

Table 6-2: Headings of the emergent main dimensions and sub-themes from the case studies of organisational and sectoral recovery after the 2010 and 2011 Canterbury earthquakes, arrived at using the grounded theory method after analysis of the case study data

Headings of the emergent main dimensions and sub-themes of organisational and sectoral recovery after the 2010 and 2011 Canterbury earthquakes arrived at using the grounded theory method after analysis of the case study data	
Main dimensions	**Sub-themes**
Organisational actions in the response phase	
Differing interpretations of pre-disaster preparedness, active versus passive measures	→ *Plans as fantasy documents* → *Prior crisis or disaster experience* → *Post-disaster key "learnings"*
Wellbeing	→ *Staff wellbeing* → *Family wellbeing* → *Community wellbeing*
Location	→ *Neighbour effects* → *Damage to organisation's assets* → *Size of the (regional) economy* → *Localisation of damage* → *Duration of closure* → *Rent or ownership of premises*
Access to resources	→ *Insurance* → *Financial resources* → *Manpower* → *Physical resources* → *Replacement supplies and raw materials* → *Efficient and effective use of resources*
Leadership	→ *Organisation ownership structure* → *Communication*

	→ *Recognising and grasping opportunity* → *Sectoral leadership* → *Leadership of the overall recovery effort*
Industry sector	→ *Intra-sectoral collaboration* → *Inter-sectoral collaboration* → *Type of goods and services provided* → *Make-up for lost production*
Variety and Diversity	→ *Sources of revenue* → *Geographic or locational* → *Delivery of goods and services*
Information	→ *Official sources* → *Economic sources* → *Engineering and technical information*

6.4 Organisational actions in the response phase

In the disaster literature, studies such as Turner's (1976) detail the different stages before and after a crisis. It is also vital to focus on what actions organisations and the people in them have taken in the first few moments of a rapid-onset disaster. For instance, Zolin and Kropp (2007) write about the actions of surviving businesses after Hurricane Katrina and how analysis of these actions can be used to increase business survival. As such actions involve how people actually performed; they can be used to inform organisational crisis planning strategies. However, Quarantelli (1986) cautions that information from such analyses should only be used after careful and objective consideration. This is to ascertain which particular actions are of value to the organisation before, during and after a crisis.

The response phase of the crisis for case study organisations lasted on average four to ten weeks after 22 February 2011. For the case study organisations in this work, the reactions and steps were similar for many of them in response, hence the emergence of the main dimension organisational actions in the *response phase*. The differences that emerged were based mainly on sector, location and to a lesser extent size of the organisation. The common actions organisations performed in the response phase are documented in the list that follows. The actions described are generic and were not taken in the order they are presented. Some of the actions happened concurrently and some of them occurred in sequence:

→ Earthquake occurs;

→ Building(s) evacuated, staff move to safer area and try to establish wellbeing of their families;

→ One or a few individuals took charge and verified staff wellbeing by phone, e-mail, word of mouth or social media (e.g. Facebook, Twitter). In the few hours after the earthquakes phone lines were congested making it hard to reach people. For some of the larger organisations this staff welfare verification took several days as some staff had left town;

→ Whoever was in charge (in the larger organisations, usually a group of three people) did a preliminary (mostly visual) damage assessment. This happened in areas where the building was still standing, where there was no official cordon around the building, and while awaiting expert geotechnical and structural engineering appraisal [35]. Some organisations that employed geotechnical or structural engineers as part of their operations reported using in-house engineers for these assessments. Some organisations later asked their engineers to assist with appraisals in the Christchurch region;

→ For those organisations that had to wait to get building assessments done, the organisation's leadership team met and decided on measures to be taken. Tasks were delegated to different members of the leadership team as well as to other staff. In many cases, task allocation was done by phone and e-mail. Arrangements to work from alternative premises (e.g. the homes of staff members) were made;

→ The organisation's position in relation to suppliers and customers was assessed, the critical suppliers and customers identified and in what order or fashion they would be dealt with;

→ Critical customers and suppliers were contacted and informed of the preliminary assessment for when goods and services delivery could possibly continue;

→ Communication to employees continued, using various methods. The communication usually involved further ascertaining the condition of employees, their families, their dwellings and their community. In many instances, organisations offered some kind of assistance (food packs, financial grants, laundry facilities) to employees;

[35] In most cases, people did not (officially) go back into the building until an expert assessment had been done and the building cleared for occupation

→ A short-term business continuity plan was prepared. This used information on the state of the organisation's premises, equipment, supporting infrastructure and intelligence from critical customers and suppliers;

→ Employees contacted, told the high level details of the business continuity plan and asked about the possibility of coming back to work. In the main, employees had the option of not coming back so soon after an event: some employees chose to work while others chose not to;

→ Continued development of medium- to long-term organisational post-earthquake(s) plan.

For the response phase of the crisis, organisations reported not planning too far ahead as the situation changed continuously. As organisations transitioned into the short-term recovery phase, they gradually started to look at what had occurred in relation to medium- and long-term corporate recovery strategy.

6.5 Differing interpretations of pre-disaster preparedness: active versus passive measures

Organisations were asked if they had pre-disaster or pre-crisis preparedness plans at the time of the earthquakes and if these plans were documented. Of the 18 organisations interviewed, less than half had a written emergency plan while one (T1) had a plan that was not documented. The fullness of these documented emergency plans varied widely. Comparing with the rest of the sample set, only 3% of organisations reported having a documented emergency plan when asked in Survey 2

None of the case study interviewees interpreted the questions on *pre-crisis* or *pre-disaster preparedness* to mean passive means of mitigation and preparedness like insurance or a fire extinguisher, most of which they had. They all related the questions to specific plans dealing with low probability high consequence events such as earthquakes. Their responses were likely influenced by their recent experience of earthquakes.

All the organisations spoke of not thinking of Christchurch as being a significant earthquake risk. After the 4 September 2010 earthquake, in which most of the case study organisations were

not very adversely affected, the occurrence and effects of the 22 February 2011 earthquake were even more of a surprise.

> "***the person who was [in charge] decided that it wasn't worth the additional expense, and Christchurch wasn't a risk, so we had quite solid insurance for our Wellington store and for our Auckland store, but we didn't for our Christchurch stores***" – CCBD1

Indeed, historically Christchurch was thought to have relatively moderate seismicity and the actual faults that caused the 4 September 2010 and 22 February 2011 earthquakes were previously unknown (Beavan et al., 2011). That the earthquakes happened and caused such damage and disruption shows that organisations should have plans that encompass the broadest range of hazards including ones they have not thought of.

> "***we all sort of expected that after [4] September [2010] the worst was over, and we were probably going to be safe after that, but no, we were obviously quite wrong***" – CCBD1

6.5.1 Plans as fantasy documents[36]

Most of the organisations listed having plans for fire, low cash flow and pandemics; what they called *normal* things, but not plans for earthquakes. This makes these organisational plans fantasy documents as organisations think they are prepared (see chapter 2.3.3) but their plans bore little resemblance to what they would need to do in the event of a disaster. Only one of the organisations interviewed (ICT1) had specific plans in the event of an earthquake. It appears that the majority of the case study organisations made plans for hazards they thought more likely to occur (e.g. fire), hazards that were sector specific (e.g. shelf collapse) or hazards they had experienced (e.g. pandemic). Additionally, some organisations reported that they felt the overwhelming nature of the events in Canterbury would have rendered such plans *almost useless*. This included both organisations with and without plans. This suggests that organisations may have misconstrued the purpose of planning and of having plans. The value of prior planning lies

[36] The phrase *fantasy documents* is from the book Mission Improbable: Using *Fantasy Documents* to Tame Disaster by Lee Clarke (2001).

in knowing what steps to take in the event of a disaster and may also help to minimise the effects of a disaster. In a study on organisational recovery after Hurricane Andrew, Kruse (1993) showed that organisations with pre-crisis planning recovered quicker after the event.

Furthermore, case study organisations expressed that in the response and early recovery phases, the ability to take quick actions and make on-the-spot decisions with limited information was important. Some of the actions seen as helpful after the event included the speedy assembly of organisational crisis teams. It can be argued that actions such as these can surely be carried out quicker and more efficiently with knowledge from prior planning exercises. However, in planning and preparing for crisis, organisations need to recognise that aside from the speed of decision making, any actions taken should be suited to the situation they find themselves in. Quarantelli (1988) and Dynes (1974) also emphasise this while case study organisation KTC1 describes it as:

> "***…as far as I know, the management do that and then we just follow our orders and their expectations…***" – KTC1

From the information provided by interviewees about pre-earthquake plans, business owners and managers were more likely to concentrate on employee safety than on business continuity which would have included what steps to follow in recovery after disaster. Interestingly, interviewees reported that in looking back at what happened in the first few hours after the earthquakes, the most valuable type of plan is one that is not too specific and is adaptable. Additionally, responses to other questions on actions organisations took after the earthquakes exposed contrasting thoughts. It emerged that prior planning would have been of value; for instance in procedures used to verify staff wellbeing. They also emphasised that having a plan is one thing, rehearsing that plan is equally vital. Interviewees detailed being quicker off the mark on 22 February 2011 for the response phase because of some of the motions they had gone through after 4 September 2010. Some interviewees pointed to the possible inclusion of regular practise drills as part of their organisation's post-earthquake strategy.

6.5.2 **Prior crisis or disaster experience**

In reviewing their response to a crisis, some of the preparedness measures organisations engage in afterwards may still not fully address the challenges of a wide range of disasters. In the disaster

literature, researchers have found that prior crisis or disaster experience is not that helpful when faced with a major disaster (Dahlhamer & Reshaur, 1996; Tierney, 2009). Additionally, authors such as Zhang et al (1973) and Zolin and Kropp (2007) further note that organisational hazard mitigation plans often target the response phase after disaster and may not include business continuity details. None of the interviewed case study organisations could recall their organisation ever having faced a crisis of the magnitude brought about by the 22 February 2011 earthquake. Nonetheless, it emerged that some organisations from the critical infrastructure and trucking sectors, as well as those providing essential or non-substitutable services, were used to dealing with crisis of sorts in their day-to-day operations. They said this experience helped to a degree in the response phase. However, they added that this limited experience was not adequate for the kind of response or business continuity required after a major disaster. It appears that exposure to minor crisis may not be adequate preparation for a major crisis. This point, on the scale of disasters, has been emphasised by Quarantelli (2006).

6.5.3 **Post-disaster key 'learnings'**[37]

One of the outcomes after the acute phase of a crisis has passed is the need to identify key lessons that organisations can take away from the experience. These lessons may be used to inform corporate strategy for post-disaster recovery or to help manage crises better in the future. Other disaster researchers such as Stern and Sundelius (2002) write that learning from a disaster should be an objective exercise if organisations are to get the most value from it. In essence, all the case study organisations have used the earthquakes as a learning opportunity, but to varying degrees. For instance, ICT1 noted that their emergency plans did not have building re-entry procedures and did not make provisions for tsunamis. The organisation has since included both of these parts into their updated emergency plans. H2 on the other hand believes that there is not much that organisations can do about low probability, high consequence events although they reported plans to improve the organisation's health and safety arrangements in future.

[37] A word that was used repeatedly by interviewees.

6.5.4 **Organisational resilience**

Organisational as well as disaster researchers are interested in what makes some organisations adapt better in crisis. Organisational resilience has been put forward as a differentiator in how organisations handle and survive crises (Seville et al., 2008; Sutcliffe & Vogus, 2003; Tierney, 2008). The word *resilience* was used constantly, mainly in reference to the people of Canterbury, after the 4 September 2010 earthquake. Interviewed organisations were asked how they would define the resilience of an organisation, what the traits of a resilient organisation were from their perspective and if an organisation being resilient added any value. Seville et al (2008) define organisational resilience as *the ability to survive crisis and thrive in a world of uncertainty* while Hamel and Välikangas (2003) describe resilience as *the ability to dynamically reinvent business models and strategies as circumstances change*. When asked, the case study organisations' definitions of organisational resilience embodied that of both Seville et al and Hamel and Välikangas. The organisations thought of a resilient organisation as:

> ***"…essentially each organisation is there to do something and if it is able to continue to be effective in doing that, despite the entire world changing around it, then it's probably reasonably resilient*** " - T1

> "***…being able to ride this tough time out is probably the biggest measure I have of resilience…The other one is for me personally, is psychologically getting through it***" - KTC2

> "***…two levels to me for organisational resilience….The first level would be the resilience within the people, that your people aren't cracking up, especially ones in senior positions, you've got to be able to handle the psychological impact….the second one, after people resilience is the resilience of your processes, your procedures and your organisational structure.***" – ICT1

Even with the different definitions of resilience, there was agreement on the importance of resilience to organisations. Interviewees also portrayed resilience in both proactive and reactive terms. There was no one particular element of resilience that was mentioned more frequently by an individual sector. Some of the attributes interviewees said could lead to a resilient organisation:

→ People employed, skills;
→ Leadership;
→ Networking of the organisation;
→ Financial position;
→ Adaptation;
→ Location;
→ Diversity;
→ Maintaining relationship with customer base;
→ Good knowledge of supply web;
→ Disaster plans;
→ Knowing interdependencies between departments in the organisation;
→ Good, solid infrastructure and equipment;
→ Robust organisational processes, procedures and structures;
→ Flexibility; and
→ Organisational (personnel) succession plans.

In chapter 10, the attributes of organisational resilience described here by case study respondents will be contrasted against those in the 13 indicator model developed from the work of McManus (2008) and Stephenson (2010).

6.6 Wellbeing

Organisations cited staff wellbeing as top of the list when they were asked what factors influenced recovery. However, it emerged that there are multiple interrelated aspects to this wellbeing.

6.6.1 Staff wellbeing

All interviewees reported that staff were the most important aspect of the recovery of their organisation. As organisations are made up of people, recovery for the organisation is linked to recovery of staff. However, for staff to devote their energies to organisational recovery, their primary concerns, e.g. family welfare, need to be taken care of. In the case of disaster, staff need

to take care of family needs before turning to those of the organisation. In Canterbury, there was recognition that the personal wellbeing of staff was crucial in tackling the response to the disaster and in the work to be done during the recovery phase, for instance in the case of staff working longer hours to make up for lost production.

> "***…you have to have good people, because without execution a plan is worth nothing…having a disaster recovery plan is a good place to start, and so long as you have recruited well and you've got the right people in the right positions***" – ICT1

All organisations also reported paying attention to the number of hours staff worked. Organisations also worked hard to ensure staff redundancy was a last resort in already turbulent times and that work should be one source of certainty. The author spoke to staff in some of the case study organisations and heard staff reports of being inspired by the level of care shown by management especially without being prompted. Corporate support for staff has been documented after other disasters also, for instance after Hurricane Andrew (Sanchez, Korbin, & Viscarra, 1995). In Canterbury, organisations mobilised resources to support their staff; providing for example basic services such as laundry and shower facilities. Some organisations, for instance BS1, also assisted staff by paying for professional advice such as insurance claims consultants. Essentially, this is an interpretation of Maslow's (1954) hierarchy of needs, where recovery starts with the fulfilment of the individual's *basic* needs before moving on to other aspects.

6.6.2 **Family wellbeing**

Employee wellbeing is very closely connected to family wellbeing. Employers recognised that ensuring their employees were doing well was in itself not enough. They also had to look into the wellbeing of the employees' families and personal situations as this affected the employees' performance at work and their decision to remain in the greater Christchurch area altogether. For example, some ICT and critical infrastructure organisations reported that some employees voluntarily left their employment due to family considerations. Measures taken to mitigate this included giving staff the choice to relocate and still retain their jobs. They reported that, in the main, this was a better option than losing staff altogether and helped with team spirit in the

organisation[38]. These efforts made staff feel more valued which often translated into increased productivity.

> "***… it is important that we were given time to be with our families, we were given time to have time out, we were given time to fix our own earthquake things that were going on***" – KTC1

6.6.3 Community wellbeing

To extend the concept of wellbeing further, employees and their families are part of communities. To a certain extent, the organisation benefits from contributing to the recovery of the community. The organisation relies on the community for provision of resources like employees and in some cases for custom. Conversely, the community relies on the organisation for provision of goods and services. Some organisations, e.g. ICT1 and FMCG2 reported that in certain cases they were aware that they possessed more resources than earthquake ravaged communities and felt that they had a duty to help the community. This also conveys that community post-disaster recovery may have an influence on the recovery of organisations. For instance, Elms et al (2012), Chang and Shinozuka (2004), Paton (2006) and Mayunga (2007) demonstrate how organisations and the community are linked in recovery. These different studies show that economic recovery and social recovery are very closely related and one cannot occur without the other. Therefore, planning for one aspect of recovery should take related aspects into consideration.

6.7 Location

Location has often been cited in disaster studies as important to organisational recovery (Chang & Falit-Baiamonte, 2002). Organisations were asked why they chose the locations they were in prior to the earthquakes. Reasons given covered the multiple aspects of location and included the benefit from proximity to surrounding organisations; suitability for their type of (specialised) business; to be with like businesses; as well as a sense of place and belonging as the owner had lived in that area all their lives. These aspects that were an advantage prior to the earthquake in

[38] One point that was not discussed was if and how organisations will maintain, in the long-term, the 'satellite' offices set up in response to staff needs after the earthquakes.

some cases turned out to be disadvantages after. For instance, organisations that selected the area they were in for its benefits pre-earthquake, but whose soils liquefied due to the earthquakes.

> "***…every quake we get we have movement. We still have movement in the slabs, even when we haven't got quakes, because the ground underneath is soft***" – ICT1

6.7.1 Neighbour effects

In some cases, the buildings next to or nearby an organisation's premises were damaged and red-tagged as unsafe to enter. This had cascading effects to organisation's whose premises were not damaged but could not be accessed until the damaged building was repaired or demolished. This point is closely linked to the duration of closure of an organisation's premises, their ability to access resources such as customer information, as well as delays in getting buildings technically assessed and if necessary repaired or demolished.

> "***By the [22] February [2011 earthquake], I had nothing, I still haven't got my business. CERA won't let us in there…we're in the fall zone of the Grand Chancellor [hotel] and [named] Bank***" – H2

6.7.2 Damage to organisation's assets

The extent of damage to the organisation's premises and equipment as a result of the earthquakes can have an effect on the recovery of organisations. Some assets were damaged by the ground shaking, some by falling over and others by objects falling onto them.

> "***initially we made the decision to reopen the warehouse as soon as we could because we needed to keep our other branches trading, because that was potentially impacting on the whole business, compared to the fact that we already just lost, or had three Christchurch stores shut down***" – CCBD1

However, the repair or restoration of physical assets alone is not enough to ensure that an organisation will recover post-disaster. Other elements such as loss of staff or customers might also contribute to an organisation's demise. Alesch et al (2009) demonstrated as much in their work on community disaster recovery.

6.7.3 Size of the (regional) economy

In this case, the economy includes not only the gross domestic product (GDP) but also the variety of goods and services produced in the greater Christchurch area and Canterbury region. The economy was robust enough in size that even with the closure of the CBD, other sectors and areas could still function.

> "***…we're still operating, we're still making a profit, and we're in a relatively robust economy down here compared to where other parts of [organisation] are in Europe and the United States, so we're actually doing quite well from a numbers perspective***" – ICT1

6.7.4 Localisation of damage

This sub-theme is very closely related to the point above, the size of the region's economy, and is a fundamental characteristic of the Canterbury earthquakes. The (physical) damage caused by the 22 February 2011 Christchurch earthquake was *localised* or concentrated in Christchurch's CBD and eastern suburbs. In other work, Chang (2010) found that the widespread damage after the Kobe earthquake was a barrier to recovery. Consequently, after the Canterbury earthquakes, some organisations moved to alternative accommodation. This accommodation was in other parts of the country, region or areas of Christchurch that had less or no damage. This was also because of the non-interruption or quick restoration of critical services essential for the functioning of many organisations. The geographic localisation of damage also meant that first, resources could get to affected organisations and second, unaffected entities from outside the affected area could send resources quickly.

This sub-theme is related to access to resources detailed in section 6.8. Additionally, some of the organisations with their headquarters in Christchurch narrated that localisation of the damage meant that important records stored by the head office could be retrieved. CCBD1, whose headquarters and main distribution centre are both in the greater Christchurch area, detailed that if the damage had been more spread out, this would have affected their organisation severely.

6.7.5 **Duration of closure**

The length of closure of an organisation's premises can also influence recovery especially for those that cannot relocate or those that can relocate but have no access to equipment, stock or business information. This is also linked to the organisation's position in the supply web as the longer the organisation is disrupted, the greater the disruption to their suppliers or customers and so on.

> "***…we've learnt a lot, that we can move around, we can move the business around to other places and continue working….we've got so many sites that we can just get things moving around…we're fortunate that we're quite a large business.*** " – BS1

Duration of closure included that caused by intermittent downtime brought on by buildings or equipment needing to be checked after every significant aftershock. Also, the duration of closure for an organisation can have other effects such as customers not returning once the business has re-opened. Some of the case study organisations, e.g. LTC1 and CCBD2, reported engaging in extra promotional activities to remind customers that they had re-opened. In the disaster literature, Nigg and Tierney (1990) found that the length of closure of an organisation may affect the return of customers.

6.7.6 **Rent or ownership of premises**

It was evident from information provided by some of the interviewees that the issue of rent or ownership of their organisation's premises played a part in recovery. Dahlhamer and D'Souza (2004) write that building owner/occupiers are more likely to engage in preparedness activities than renters. From Survey 1, 73% of organisations reported renting their organisation's premises. Some of the (renter) interviewees spoke of wanting to engage in repair, restoration and reinforcement work but that this was dependent on the building owners. Organisations report that in many cases, they did not have much of a say in the level of repair or restoration decisions after the earthquakes. Some owner/occupier organisations interviewed detailed ongoing plans for seismic retrofitting in light of the earthquakes.

Renting a building could be an advantage as the renter can walk away and not have to think about issues to do with building repair. However, organisations also spoke of being locked in to

their pre-earthquake leases even for buildings that would likely be demolished. This also contributed to the delays in insurance payments. In the context of the Canterbury earthquakes, it can be argued that rent or ownership of business premises was not very significant for most of the organisations. This is because both owners and renters faced similar problems in accessing qualified personnel, e.g. structural and geotechnical, to assess building and ground damage. Additionally, both owners and renters were affected by delays, for example in getting insurance payments (see chapter 8 for more detail). It is important to note that the majority of the sample (see chapter 5) were renters.

6.8 Access to resources

Resources can be financial, physical (e.g. machinery), manpower (e.g. expert services), basic raw materials and information. For the overall sample, this main dimension and its sub-themes is related to the localisation of damage discussed in section 6.7.4. From the case study organisations interviewed and for this main dimension of access to resources, the small- to medium-sized enterprises (SMEs) faced more difficulties in accessing some resources than the larger organisations (see appendix I for detailed analysis of entire sample by organisation size). For instance, quick access to finance to purchase goods and services necessary for the recovery process. It is clear from the case studies that smaller organisations did not have the capital reserves that larger organisations did. For instance, H1 spoke of head office providing a lawyer she would otherwise not have been able to afford if she had had to pay for the service. This difficulty accessing resources means that SMEs are more likely to struggle to recover following the earthquakes.

Additionally, it became apparent that the resources required after a regional disaster can be in excess of what the organisation might require for a day-to-day crisis when costs such as relocation, new equipment and extended revenue decreases are factored in. Organisations must be prepared for sustained periods of financial underperformance and have a plan to weather such periods.

> "***The building was closed and had to be inspected and so on, so we were out of there for six weeks, two months. Gee that's costly, I didn't realise how costly it was to move out of an office and set up somewhere else***" - KTC2

SMEs are more dependent on other ways to carry on operations after cash flow is disrupted such as money borrowed from family and friends or on credit. H2 pointed to using family savings to make payments for the business. This was in part because her insurance settlement was delayed. This shows that for small business owners, their personal wealth is often tied up in their business which compromises their financial security. Berger (1998) and Avery (1998) found that small business owners often use personal assets to finance their organisations.

Furthermore, even among the SMEs there is a difference between those that are small and those that are medium-sized. The interviewer noticed that the very small organisations with fewer employees spoke more frequently about the possibility of closing the business. This was in contrast to larger organisations that had more employees who could become redundant in the case of organisational closure. The medium-sized organisations often had on their payroll in-house professional services such as lawyers and accountants that the smaller organisations did not have.

6.8.1 Insurance

In the disaster literature, Kunreuther (1996, 2008) has written extensively on the use of insurance as a form of disaster mitigation. After the 22 February 2011 Christchurch earthquake, insurance and the delayed settlement of insurance claims emerged as a massive issue. The continuing occurrence of earthquakes in Canterbury was a major source of uncertainty for insurance companies who delayed payment to policyholders as they assessed the risk. Additionally, the insured costs of the earthquakes were unprecedented (Munich Re, 2012). The majority of organisations interviewed talked of the delayed payment from their insurance companies as having an adverse effect on their recovery as it restricted some of the decisions they could make. This was especially so for the small organisations. The system dynamics analysis in chapter 8 shows what some of the consequences of this delayed or non-payment of insurance were.

6.8.2 Financial resources

This is linked to the point on delayed or non-payment of insurance (section 6.8.1). Most small organisations do not normally have large amounts of cash flow in day-to-day operations (Dodge, Fullerton, & Robbins, 1994). After the earthquakes in Canterbury, low levels of organisational cash flow were magnified. The small organisations in the study spoke of still having to pay bills

(e.g. mortgages) even as there was no revenue coming in for a certain period after the earthquakes. This put a further strain on their organisational and, in some cases, personal finances.

Organisations reported that the quick action by Central Government, after both the 4 September 2010 and 22 February 2011 earthquakes, to assist organisations with 50 employees or less has been hailed as one of the best decisions to come out of the Canterbury series of earthquakes. The Earthquake Support Subsidy (ESS) enabled many organisations to consider their decisions carefully before taking action in those crucial response and early recovery periods. It also enabled them to retain staff.

Additionally, one of the FMCG organisations pointed to Central Government sending cash to Christchurch as an aid. Due to infrastructure damage and a great demand on what infrastructure was available, electronic point of sale terminals (EFTPOS) in stores did not work. Central Government printed more money that they sent to greater Christchurch which enabled customers to use cash to purchase goods and services.

6.8.3 **Manpower**

This includes specialist services such as those to do with accountancy, tax and law which are usually functional roles in medium- to larger-sized organisations. Access to resources also includes trained personnel who can work in the organisation once it is trading again. For example, the hospitality organisations related how they had to let go of their trained staff due to their inability to pay them as they waited to re-open. This is one of the consequences of inadequate financial resources discussed in the previous section (6.8.2).

For organisations resuming operations after the earthquakes, training new staff may affect the organisation's efficiency at a crucial time in its recovery. This is because resources such as time and money which could be targeted at recovery activities (e.g. advertising) would be channelled to new staff training. New staff are not as efficient with organisational processes as longer serving staff which leads to lower productivity (Guthrie, 2001).

Some organisations brought in assistance from other parts of their organisations, for example Auckland or Wellington to relieve those on the ground in Christchurch. This turned out to be

both a positive and a negative. The positive was that the people in Christchurch could rest and also take care of their personal situations. The negative was that some Christchurch personnel felt the visitors were stepping on their toes in essence, which caused some friction between the locals and the visitors. Also, there was a period of adjustment as relief managers and the teams they had to work with took time to get used to each other. Meanwhile, ICT and trucking sector organisations spoke of facing a skills shortage prior to the earthquakes which was exacerbated by the earthquakes. They also spoke of qualified people voluntarily leaving their employment which worsened an already bad situation.

> "***…how much time it takes for constantly sending this information all the time.***" – H2

6.8.4 Physical resources

With limited monetary or physical resources, it is difficult to relocate even if an organisation leader or owner wanted to.

> "***…with all the specialised software…specialised equipment that we use….We couldn't have worked without the equipment, especially the computers***" – KTC2

For location specific industries such as hospitality their situation differed slightly. In order to relocate they had to find the right premises to house their equipment and with all the necessary utility services connected. They were also subject to sectoral health and safety regulations that have to be met before they can serve customers or employ staff.

6.8.5 Replacement supplies and raw materials

An organisation's access to resources includes the raw materials or replacement supplies they need to deliver goods and services. This is influenced by other parts of their supply web including but not limited to supplier organisations as well as critical infrastructure such as water, electricity and roads.

> "***…I tried to buy from local people but they couldn't supply because they were affected…***" - LTC1

Organisations also needed to access stock and records in damaged buildings. However, for some this proved difficult.

> "***…one of the key stresses after the quake was the fact that we didn't have access to our stock in the centre of town, and that took some fights, for want of a better word, with Civil Defence…we didn't have earthquake insurance, so it was all sitting in the centre of Christchurch uninsured***" - CCBD1

6.8.6 Efficient and effective use of resources

The urge to use resources quickly in hopes that this will lead to a quicker recovery can result in a waste of these resources. The access and availability of resources is intertwined with the effective and efficient use of these resources (Gladwell, 2000). Effective in this thesis means that *the intended and actual outcomes are the same*. As recovery can be long and drawn out, resource use should be spread out and resources used at the right time in recovery to achieve the most return on their investment.

> *"**until the building owner decides what he's going to do, there's really no point in me even going to my lawyer to see what I can do as far as my lease is concerned… if I go to my lawyer now, it's costing money that I don't really need to spend at the moment because I'm probably asking questions that I can't get answers to**" – H2*

6.9 Leadership

In the aftermath of a crisis, leadership that is visible and decisive is vital for the organisation. Leaders should also be inspired and inspiring. Chamlee-Wright and Storr (2008) write how inspiring leadership helped the recovery of some communities after Hurricane Katrina. It emerged in interviews that the leader's primary roles are to take charge, to make decisions and to provide vision to staff and others outside the organisation that the situation will get better. From the organisations interviewed, the role of the leader was slightly different depending on the size of the organisation and the ownership structure. In the larger case study organisations that had a lot more employees and different departments with different people in charge of those departments, the leader's responsibilities included overseeing the entire organisation's response

and recovery plans. The leader's role was that of *coordination* between the different departments as well.

In all the case study organisations, the leadership mantle was taken up by those already in leadership or management roles prior to the earthquakes. Quarantelli (1986) found that in disaster existing chains of command do not usually break down even as people may take on extra roles. Interviewees reported that in the response phase of the crisis, the leaders mainly made decisions and prioritised activities in the very short-term whereas in the recovery phase their role was to balance short- and long-term recovery priorities and look at corporate strategy. Apart from decision making and prioritisation, planning and the implementation of plans turned out to be extremely important. Also, different ways of thinking were required and in evidence in the different phases of the crisis (more on this in chapter 8). KTC1, T1 and T2 resumed operations a short time after the event or did not close at all. They relayed how in the days following the 22 February 2011 earthquake, their organisations had to deal with the crisis as well as with business-as-usual involving existing customers.

Organisations soon understood that leadership in normal times is not the same as leadership in crisis and that different styles of leadership are required for the two situations. In fact, from the interviews, one lesson is that even in crisis, the style of leadership needed for the different phases is varied. The response and early recovery phases require an almost autocratic style of leadership while the medium-term phase requires more of a consultative style. For some organisations in this study, it was not just about the leadership but also where they came from. Organisations report that they brought in leaders or managers from other parts of their organisations partly to relieve those who were from Christchurch but also because the job had changed and increased in scope. Of note was the interaction between *local* people and *outsiders;* it was apparent that even in the same organisation there were several sub-cultures. There sometimes was local resentment at being told by outsiders what to do and how to do it. From reports, in many cases it was the people who came from outside the region who needed to adjust to *how we do things around here*. This was on top of working in a disaster setting.

6.9.1 Organisation ownership structure

Under leadership are also included characteristics that determine the structure of an organisation and how decisions are made. These characteristics include the ownership arrangements, lines of

communication as well as external influences on the organisation's recovery. Organisations that are franchises or part of larger concerns were able to get help from their franchise or from other parts of the larger organisation they were a part of. However, franchisees had less freedom to manoeuver and adapt as they were bound by franchise regulations. Branch organisations got help from their corporate headquarters while standalone organisations belonging to a larger group also got offers of help from sister companies (see section 6.8.3 on manpower).

> "***…We brought in staff from Auckland and from Timaru, they were really good, and we put them on our trucks, they were very experienced people***" – T2

6.9.2 **Communication**

After the earthquakes, communication, modes of communication and quality of communication were vital. This was both within and outside the affected organisations. A crucial aspect is that after the Christchurch earthquakes, the means of communication functioned. It is possible that in bigger disasters, means of communication can be cut off which would make recovery even more difficult as the exchange of information is so important. Organisational leadership also needed to communicate with the world outside the organisation, i.e. with the actors in the organisation's environment. This included being in touch and working with customers, suppliers, local and national authorities as well as the public at large if necessary. Crucially, the messages communicated must be the right ones (see also chapter 6.12 for the link between information and communication). For instance, communication to customers to assure them of delivery of goods and services.

> "***…all on a one to one, we had lots of meetings, lots of gatherings [within the organisation and with customers]***" - KTC1

Within the organisation, communication was needed to keep the staff informed of what was going on, that there was a response and recovery plan, what the plan was and that things were under control (as much as is possible during crisis times). Staff needed re-assurance and when they knew that there was someone in charge they were encouraged to do as much as they could towards the recovery of the organisation. Some of the organisations pointed out that an organisation facing and getting through crisis together was the best team building exercise.

In some organisations, new roles were defined for the response and recovery effort. This was in essence a new organisational structure which brought with it the need to establish new channels of communication in addition to those that already existed. Palen (2007) writes of the emergence of temporary organisations and structures after disaster while Tobin (2007) speaks of incorporating this feature in hazard planning.

6.9.3 Recognising and grasping opportunity

All the organisations interviewed pointed to the disruptive nature of the disaster even as the different organisations were unsettled to different levels. As it is not possible to be prepared for all crises, adapting to the changed and still changing disaster landscape is crucial. Findings by Dervitsiotis (2003) as well as Boisot and Child (1999) point to an organisation's ability to adapt as one way of surviving through turbulent times. Some interviewees spoke of their pre-earthquake organisational expansion and/or improvement plans having to be put on hold, revised or discarded altogether. However, there was also recognition that there were opportunities that organisations could grasp in the response and recovery phases. Some of these opportunities included exploring what help was available and who to ask for this help. As well, organisations expressed that adaptability was one way they reacted to the crisis, as a way of getting ahead and staying ahead in an altered environment and market.

> "***…the whole dynamics of Christchurch has changed, so you've got to think, "Well will that work or can I do something else better?" And yeah, so that's the sort of the beginnings of the recovery plans.***" – H2

6.9.4 Sectoral leadership

Some of the respondents recognised the importance of their industry sector and their organisation's place within the sector. They rose to the challenge and took charge of coordinating their sector's response to the crisis. However, this had to be done in such a way that they did not cause offence to the other organisations in the sector. Some of the reasons for this were that it was easier to get people to cooperate willingly and also that the sector would still need to work together after the response and recovery efforts.

> "….***the task of coordinating the entire industry to fix the problems in the [niche industry sector] area...had to work with all our competitors really to make sure,***

because if everybody is fighting each other and so on, it just doesn't work in that environment, it has to be a team approach so we had to coordinate and talk daily with all our competitors and figure out who was going to do what' – T1

In the organisational literature, cooperation between competing organisations is termed *coopetition*. Bengtsson and Kock (2000) have shown how competitors working together can both benefit. However, this is partly dependent on whether or not they are competing for the same resources.

6.9.5 Leadership of the overall recovery effort

Leadership of the overall post-disaster recovery is crucial as they can help facilitate the process (Hummel et al., 2007; Nakagawa & Shaw, 2004; Rubin & Barbee, 1985). Case study organisations were not directly asked who they thought was in charge of the overall recovery effort. However, it was clear from information given during the course of the interviews that there was confusion about who was *really in charge* of the recovery effort as opposed to *who was appointed to be in charge* of leading the recovery of the greater Christchurch area. There also seemed to be some confusion as to which organisation was performing which roles; this included the government agencies as well as the many business associations that were prominent at the time. This confusion sometimes led to organisations wasting time talking to the wrong people about issues of recovery or in the extreme not talking to anyone at all. The uncertainty surrounding who was in charge changed with time as more information became available. However, in some cases, the effectiveness of the plans of recovery agencies did not give interviewees confidence.

6.10 Industry sector attributes

Recovery for organisations belonging to the industry sectors in this study was dissimilar. The differing industry sector attributes and how they affected recovery are encapsulated as the signifiers of recovery in section 7.7. Additionally, in chapter 9; from the aids, hindrances and points of intervention in recovery, the critical success factors (CSFs) are a summary of what was important for each sector on its path to recovery. From the case study interviews, supported by the contextual interviews and revenue survey data, hospitality organisations were not recovering at the same rate as those from the ICT sector. This was so even when revenue data for the entire

sample set was checked. This has to do with the goods and services produced by the two sectors and where their customers were based. For hospitality, the custom was mainly local and they were dependent on customer discretionary spending. People held on to their discretionary finances after the earthquakes as they waited to see how the economic situation would evolve. For ICT, some of their main customers were outside the region and the country. As well, for those that serviced the local Christchurch market, their services were required after the earthquakes. In a study on business vulnerability to earthquakes and other disasters (Tierney & Webb, 2001), it was shown that the manufacturing and construction sectors recovered quicker than hospitality and retail. However, in Canterbury this was not the case as more organisations from the building suppliers sector struggled in short-term recovery due to low sales volumes.

After the earthquakes and depending on industry sector, there was post-disaster cooperation between organisations in the same or different industry sectors to assist each other's recovery. The industry sectors involved in specialist and non-substitutable goods and services reported that collaboration within the industry sector helped in recovery. This theme is linked to the sectoral leadership discussed above (section 6.9.4) and the awareness that the recovery of the whole sector is vital to maintain certain sectoral and economic dynamics. Other cases of inter-sectoral collaboration were between trucking and FMCG (see chapter 5).

> "***we had a number of competitors around us [in pre-earthquake location], and we've been speaking with them, because we'd like to be back, we'd like to be near each other, because obviously you feed off each other's advertising***" – CCBD1

6.10.1 Type of goods and services provided

The kind of goods and services supplied by an organisation also contribute to its recovery after disaster. This has also been documented in other work on disaster recovery (Alesch et al., 2009). For some organisations, especially those dealing with goods and services dependent on consumer discretionary spending, the organisation's recovery might be hampered as consumers spend less on items they do not consider vital. For example, high-end retail fashion might face a slump after disaster. This was a finding by other disaster researchers also (Tierney & Webb, 2001). An extension of this is that the organisation's goods and services are not required in the aftermath of a crisis. One retailer from Lyttelton said she realised that the luxury products she

sold were not needed in the three or so months after the 22 February 2011 earthquake. On the other hand, for firms providing essential and non-substitutable services, their challenge might be the ability to meet demand in the aftermath of a disaster event. In Canterbury, this was seen in the trucking, critical infrastructure and FMCG sectors.

6.10.2 **Make-up for lost production**

The possibility to make up for lost-production is also sector dependent. One ICT organisation reported that they made up for lost production after they re-opened by working longer hours. The success of this possibility though is closely linked to some of the other dimensions and sub-themes discussed such as the wellbeing (mental and physical) of the organisation's employees in the aftermath of a disaster, the amount of damage to the organisation's premises or equipment, the type of product as well as knowing which customers to prioritise. These factors are in turn dependent on other factors such as critical infrastructure availability and suppliers' ability to meet the needs of the organisation.

> "***…we probably lost I'd say three and a half to four working days … we had to catch up with overtime…But then there's getting that balance between overtime and not stressing people out at work so that they went home to their families***" – ICT1

6.11 Variety and diversity

Researchers such as Sheffi (2007), Dervitsiotis (2003) and Alesch et al (2009) have shown how important various forms of diversity are for businesses. Diversity can be in the goods and services provided, how those goods and services are delivered, the location of customers, the number of suppliers and in the location of the organisation (Hamel & Prahalad, 1996; Lengnick-Hall & Beck, 2005; Porter, 2000; Senge, 2006). From the case study organisations affected by the earthquakes in Canterbury, organisations with more than one product line or with dispersed customers or premises were somewhat able to compensate for disruption as they had alternatives. For instance, diversity in the way an organisation delivers goods and services to its customers can be crucial after disaster.

6.11.1 Sources of revenue

Customer base

The ICT sector spoke of their clientele being mainly outside Christchurch. One of their biggest challenges after the 22 February 2011 earthquake was to re-assure customers outside the region and the country that they could still be relied on to deliver. This is in contrast to the hospitality sector whose main customer base was in Christchurch.

Product

This is connected to the type of goods and services provided by a firm but even more is about an organisation not being reliant on one product or on producing different products on the same line which could be damaged in a disaster event. For instance, FMCG2 had multiple product lines some of which were in higher demand after the earthquakes.

6.11.2 Geographic or locational

Studies (Chang & Falit-Baiamonte, 2002; Dahlhamer & Tierney, 1998) have shown that the location of an organisation can affect recovery. Geographically, and for an event such as an earthquake, ground or soil conditions and proximity to the epicentre can affect an organisation. Geographic distribution can mean that the organisation has customers in different locations (e.g. Christchurch and Auckland). It can also mean that an organisation has alternative premises for operation, production or storage.

> "***…after [4] September [2010] we were surrounded by buildings that, one in particular Manchester Courts, which affected our front entrance. So we had no front entrance, so we were closed for probably three and a half to four weeks, just under four weeks.***" – CCBD2

6.11.3 Delivery of goods and services

The way in which an organisation delivers goods and services can aid recovery after disaster. For example an organisation can interact with customers from its physical premises as well as conduct business online. This also ensures a diversity of customer base as those shopping online do not necessarily have to be in the same physical location as the organisation. As well, in the

case of a disaster event damaging physical premises, the organisation can still serve their existing clientele but in a different way.

> "***…and our internet store is based just downstairs in [branch location], and that is primarily, probably 50/50 between international and New Zealand, so that's where our international access comes, is through the internet***" – CCBD1

This is of course also dependent on the type of goods and services delivered by the organisation, for example, location specific businesses such as some in hospitality might not be able to deliver online.

6.12 Information

The availability and quality of information were key to the decisions organisations made post-disaster. Information and communication are intertwined (also see chapter 9); it might be possible to communicate but still not inform. For instance the means of communication are one feature but the value of the information is also essential. Organisations on the whole were aware that things had changed. They report that in certain instances, they wanted to adapt but were partly hamstrung by the lack of credible and useful information. One retailer from Kaiapoi spoke of wanting to move undamaged merchandise to a different location in the town centre but could not access geotechnical information on the quality of the soil the new building sat on.

The availability and quality of information is closely related to the uncertainty about who was in charge discussed in section 6.9.5. As the uncertainty lessened, the quality of the information given by recovery agencies was not always of the standard useful to organisations for recovery.

6.12.1 Official sources of information

Knowing which organisation is responsible for what and who is at the forefront of the recovery effort is essential (see section 6.9.5 on leadership of overall recovery effort). Post-earthquake there were a myriad of organisations that said they were speaking for businesses but that had never been in touch with the businesses they claimed to represent. Conversely, a lot of the case study organisations interviewed say they had not contacted these emergent or already existing associations either, as they did not know what they stood for. Also affecting the recovery of

some organisations was the lack of information on the timeline for demolition, cordon removal and the overall recovery plan for the CBD.

> "***….but that sort of first six weeks was definitely the critical part – we had a million dollars of stock in the central city…..We knew that the doors were open in the stores when the staff left…..we knew that people were accessing the central city, without authority…we didn't know what was going on with it – we had no idea, and we couldn't get any information about it***" – CCBD1

6.12.2 Sources of economic information

Economic information is to do with insurance payments and other external sources of funding as well as with the general financial health of the organisation itself, the industry sector it belongs to and the greater economy it is connected to. Concerning insurance, organisations outlined how it was not just the delay in payment that was affecting their businesses but also the lack of logical explanation for why there was this delay. This was in addition to what turned out to be ambiguous wording contained in policy statements as to what their insurance policy actually covered. However, the Earthquake Support Subsidy (ESS) mentioned in section 4.4.2 was helpful.

6.12.3 Engineering and technical sources

This was one of the most difficult aspects of the Canterbury series of earthquakes in that no one had an answer for when the shaking would end or when land assessments would be completed. The continuing earthquake and aftershock sequence was one of the reasons given by insurance companies for the continued delay of payments to policy holders. The earthquakes also affected the pace of building demolition and the clearing of rubble.

> "***…when we have aftershocks…I've got to arrange with the oil company to send an engineer out, and let the engineer, as I said before, the site, what it's structural integrity is.***" – FMCG1

6.13 Sectoral comparisons

It has been shown that after the earthquakes, the sectors in this research were affected by the pre-earthquake characteristics and conditions as well as the direct and indirect effects of the

earthquakes. The CBD and the town centres in this study were the financial nuclei of the towns they are in. However, for some sectors such as critical infrastructure, ICT and FMCG, the factors that affected their rates of recovery in the short-term were more to do with the characteristics prior to the earthquakes. Some of these include the nature of goods and services delivered, the location of organisational assets, and the ability to work from alternative locations.

Additionally, the direction of the rate of recovery can be positive or negative. The ICT sector showed a more positive rate of recovery than building suppliers, the majority of whom were still reporting revenue decreases 18 months after the 4 September 2010 earthquake. In contrast to FMCG where the bulk of the organisations are part of larger groups of companies and had over 50 employees, 80% of the ICT organisations had between 1 and 20 employees and yet had a larger percentage of organisations with a positive recovery rate coefficient (RRC) measured using changes in organisational revenue after the earthquakes (more detail on RRC is in chapter 7.2). This again shows the differences in consequences to sectors after disaster and that factors such as customer location (see chapter 7.5 also) and demand for goods and services also play a part in recovery after disaster.

Still using the number of employees as a measure of organisation size[39], sectors were affected in yet other ways. For example a lot of the ICT organisations had less than 20 employees while those in critical infrastructure had more than 50 employees. Both sectors reported that the rise in demand for their services after the earthquakes necessitated more staff. Critical infrastructure solved this problem by using contractors. On the contrary, the pre-earthquake lack of skilled manpower meant that the ICT sector just about had no contractors they could call on to distribute the workload to.

For the Canterbury series of earthquakes, one of the environmental factors that appeared and was extremely important was the effects the earthquakes had on employees. Again, the earthquakes in Canterbury are unique in that they went on for as long as they did which took its toll on the people in the region. Organisations report that in the medium-term they realised that people were suffering severe fatigue which was affecting their performance at work and

[39] Appendix I has additional analysis on effects to organisations based on size calculated using full-time equivalent staff count.

consequently the recovery of the organisation. This fatigue applied to even those who did not have physical damage at home.

Organisations belonging to larger concerns such as franchises or branch organisations reported receiving support from their corporate offices as a help in recovery. However, these organisations also spoke of the strain of the ongoing earthquakes on their relationships with their corporate offices. They detailed how they sometimes underplayed the effects of the earthquakes when they had discussions with their head offices. Organisations also said people from outside their organisation's greater Christchurch office really only understood what was going on when they came to view the devastation for themselves first-hand. However, this goodwill could not go on forever. Some managers in Christchurch felt that if there was a report of negative earnings in the extended time periods after the earthquakes, their head office might decide to relocate the office to an alternative location outside the greater Christchurch region. Two of the managers from case study organisations reported how they had not shared such concerns with other staff in their Christchurch office until the situation was clearer. However, such actions even when done with the best of intentions show the amount of strain leaders may bear in the recovery period. Norwood (1997) documents how this kind of strain in disaster situations can lead to fatigue while Dynes (1974) asserts that this overwork and fatigue in disaster situations can lead to bad decisions.

Other sectoral differences were also apparent, for instance in the area of documented crisis or emergency plans. Critical infrastructure and FMCG were the sectors most likely to have organisations with documented crisis and emergency plans, more so in the critical infrastructure sector. This was the same for the practise of crisis or emergency plans. The FMCG sector partly attributed this to their sector's handling of food which requires extra attention. However, the hospitality sector also handles food and yet neither the prevalence of documented crisis and emergency plans nor the rehearsal of these plans was as high as in the FMCG sector. In interviews, hospitality organisations detailed how they had preparedness plans such as fire extinguishers or first aid kits and other measures designed to preserve life of staff and clients. However, they did not have plans for how their organisation would operate in a crisis or in recovery after a crisis. In essence, the organisations with plans for life safety were prepared for hazards they thought were likely to affect them and did not take in broader hazard risks. Analysis of the sample shows that the hospitality organisations had fewer employees than FMCG

organisations: organisational size may be a factor in the level of preparation for crisis. Some of the organisations that did not have crisis or emergency plans pointed to the fact that these plans would not have been useful after the earthquake. However, prior planning may mean that the organisation has a set of steps to follow in disaster that may help them recover quicker. Other disaster researchers (e.g. Zolin and Kropp (2007), Zhang et al (1973), Corey and Deitch (1987) and Tierney (2004)) found that preparedness was not a significant factor in recovery but that larger organisations were the more likely to have emergency plans.

None of the sectors reported being affected greatly by the inability of suppliers to meet demand. However, disruption to business operations took the form of customer issues, the other side of the supply web (chapters 5 and 7 contain more detail on this). This was especially highlighted in the hospitality sector because of their direct link to customer discretionary spending. Other sectors such as FMCG also reported having customer issues; customers could not access their premises due to damaged road infrastructure or nearby buildings and in some cases thought they were closed. Trucking and FMCG organisations reported having the bulk of their custom from their local place of business (e.g. Christchurch or Kaiapoi) and yet just after the earthquakes, the goods and services of truckers were more in demand than for FMCG.

From a sectoral perspective, industry leaders spoke of a critical mass of organisations to make the sector viable in the region. This means that if the earthquakes shocked one organisation into moving out of the region, then the benefits to remaining organisations may decline and lead to a mass egress of organisations from the region. Considering the interdependence between sectors, the implications of one sector leaving the region might be that other sectors also leave the region. For instance, as explained in chapter 5, the ICT sector is considered a key high-growth sector in Canterbury. It has also been described as a pull sector for the region (Canterbury Development Corporation, personal correspondence, 2012). This means that the presence of the ICT sector leads to the establishment of other organisations supplying goods and services to them. If they were to leave Canterbury, this may mean that these ICT supplier organisations may also leave or close. The interdependence between sectors will also be illustrated in chapter 8.

The organisations in the geographic sectors shared some similarities in the pre-existing elements that led to some of the consequences for them. For instance, they all had a large number of

unreinforced masonry buildings that proved vulnerable to the ground motions produced by the earthquakes and had to be torn down. Organisations occupied these unreinforced masonry buildings for various reasons. They reported that the rent was cheaper but importantly, these organisations had locational advantage in the number of customers they had in close proximity almost every day. This advantage turned into a disadvantage after the earthquakes as they lost their premises. More organisations in Christchurch CBD had a higher closure impact factor than those in Kaiapoi or Lyttelton Town Centres. For the Christchurch CBD, their plight was even more concerning as the cordon that was around the city was there for an unprecedented amount of time when compared to other big disasters outside New Zealand such as the earthquake in Santa Cruz (Comerio, 2011). The cordon was placed there mainly for the public's protection due to the number of unsafe buildings that had yet to come down. The cordon also acted as a barrier to access of premises for those whose premises were located within the cordon.

The recovery of the Christchurch CBD and the organisations to be based there depends partly on what will be contained in the plan for recovery. Some retail organisations that were in the CBD spoke of not wanting to go back if their competitors, with whom they shared mutual benefits such as a shared customer base, could not go back. Some of the reasons given for organisations not being able to go back were that they would be locked into leases they could not get out of or that the part of town they had moved to was more ideal than the prospect of going back to the CBD.

6.14 Chapter summary

In this section, case studies were used to illustrate how vulnerable organisations can be to hazards and that recovery is a complex operation that involves collaboration and alignment with multiple actors from different sectors. All the industry sectors involved in the case studies reported being affected in one way or another, positively or negatively, by the earthquakes. Consequently, aggregated regional or national reports of disaster effects mask the true extent of damage, physical and otherwise, that disaster can cause.

The findings from the case studies corroborate some of the findings from the contextual interviews and survey data. From all three points of data collection, staff, access to resources, some form of business continuity planning as well as information and communication are vital

in recovery. Additionally, neighbourhood effects and industry sector attributes such as type of goods and services delivered also affect post-disaster recovery

However, from the myriad components that came together to affect operations, many of the facets of the rate of recovery in the short-term are not entirely dependent on measures organisations take prior to disaster. As the organisations themselves stated, a certain level of organisational preparedness is helpful, however, measures at the level of the organisation may prove inadequate for a disaster on a regional scale such as happened in greater Christchurch. The characteristics of the event and the ecological conditions that resulted from that were also at play. For instance, the majority of organisations had insurance and yet they still faced difficulties in insurance companies settling claims. Other ecological factors relate to the recovery decisions that were made after the earthquakes such as decisions on cordons and access to buildings. An organisation's actions are governed by its environment to the extent that the organisation is dependent on this environment.

Furthermore, investigating sectoral and spatial effects of earthquakes is necessary for determining what actions organisations can take to prepare for as well as reduce the effects of disaster. The actions and decisions taken in the different stages of the recovery process also act to inform recovery. Knowing what influences organisational and sectoral recovery, and at what point in the recovery timeline, can be used to inform policy decisions. This knowledge can also contribute towards increasing organisational and sectoral disaster resilience.

The next chapter brings together results and analysis from the quantitative and qualitative parts of this research to determine the most significant contributors to recovery for organisations in the greater Christchurch area after the 2010 and 2011 earthquakes.

7 Significant contributors to sectoral and organisational short-term[40] recovery

This chapter presents results of the investigation on whether the determinants of organisational and sectoral short-term recovery documented after other disasters are the same for Canterbury after the 2010 – 2011 earthquakes. These contributing factors of short-term recovery from other disaster events were reviewed, based on the existing literature on disaster recovery, in chapter 2. In this thesis, the determinants of short-term recovery are called components and are arranged into three groups of contributors. The contributors are: (1) level of organisational or sectoral resilience; (2) pre-disaster characteristics; and (3) direct and indirect post-earthquake effects. The contributors and components of organisational and sectoral short-term recovery are correlated against a sectorally comparable measure of short-term recovery, post-earthquake revenue, that was articulated by the organisations participating in this research. Results from the correlations are used to determine the effect size, if any, that each contributor and component has on short-term recovery. Thereafter, based on the correlation results and the case study and interview data, signifiers of short-term recovery are arrived at for organisations and sectors affected by the Canterbury earthquakes of 2010 - 2011.

It is worth remembering that every disaster is unique and in Canterbury there were multiple elements that made this so. First is that organisations faced a *series* of earthquakes since the first M_W 7.1 on 4 September 2010 as opposed to just one major event. The continuing earthquakes and aftershocks acted to reset the recovery clock for organisations thereby making it more challenging to advance from the mindset of response to recovery (in general) both of which require a different set of skills. Second is that the earthquake of 22 February 2011, although smaller in magnitude (M_W 6.3) released more energy close to the Christchurch CBD than that of 4 September 2010. The 22 February 2011 earthquake showed some of the highest vertical peak ground accelerations (PGA) associated with an earthquake (Bradley, 2012). As well, the cumulative effects of multiple earthquakes caused more damage. Third is that the physical effects of the earthquakes were localised at multiple levels within a larger system. The first level of localisation was that the event was within New Zealand and the second is that the effects

[40] In this chapter, references to recovery are taken to mean recovery in the overall sense to differentiate from recovery in the short-term. See section 7.1.1 that follows.

were contained to within the South Island of New Zealand. Lastly, the physical effects were more pronounced within the Canterbury region: specifically to certain parts of the greater Christchurch area such as the CBD and eastern suburbs of Christchurch. This localisation enabled assistance and resources for earthquake damaged areas from other parts of the region and the country. This was in two primary ways. First, assistance and resources could get to the affected organisations and second, unaffected parts could send assistance and resources quickly. For instance, organisations with premises in earthquake damaged locations were able to relocate to undamaged areas or personnel available from other parts of the region or country could get to the greater Christchurch area. In addition, organisations with headquarters or primary distribution centres in the greater Christchurch area, described how recovery would have been made more difficult if the severe damage caused by the earthquakes had been more widespread (see sections 6.6.4 and 6.7 for more).

Consequently, some of the lessons from this work are singular to the greater Christchurch area. At the same time, some of the lessons are general enough that they can be applied to other organisations, inside and outside New Zealand, to better prepare them for crises or to help them recover afterwards. Again, the analysis presented in this section (and in chapters 8 – 10 that follow) is based on combined results from the surveys[41], contextual interviews and case studies presented in earlier chapters.

7.1.1 Disaster management cycle – response and short-term recovery

As was pointed out in the introductory chapter of this thesis, the disaster management cycle is characterised by different, overlapping, phases (see section 1.4 and for more detail). The data for this thesis were collected in the *response* and *short-term* recovery phases after the earthquakes in Canterbury. Response is the time period immediately following a disaster event when essential services are restored. Short-term recovery is the period up to two years after a disaster event. Consequently, it is important to remember that the results in this chapter are a reflection of the situation in the post-earthquakes response and short-term recovery periods. It is the opinion of this thesis that the short-term recovery period can be described as a transitional, chaotic post-

[41] Lyttelton did not take part in Survey; two of the components used to calculate the more significant contributor to recovery were not used for the Lyttelton sample as those data were collected in Survey 1.

disaster phase that organisations need to go through in trying to meet the objective of long-term recovery. For instance, from section 2.3.3, Turner describes the first stages after the occurrence of a crisis as having *ad hoc adjustments which permit the work of rescue and salvage to be started*. This corresponds to the response phase. Furthermore, Alesch et al (2009) have written on how both the response and short-term recovery after disaster can be characterised by uncertainty and ambiguity. Therefore, it should be noted that the measure of recovery used herein is also affected by the time span of the work, i.e. the response and short-term recovery period. Additionally, it should be kept in mind that the statistical instruments, correlation and regression, used in this chapter to verify cause and effect have been used on data collected during the very dynamic situation after the earthquakes. The dynamism and complexity of the Canterbury system post-earthquakes is captured in chapter 8. The numerous interactions between the system agents illustrates that the interactions in the response and short-term recovery phases after disaster are characterised by different behaviour leading to different emergent scenarios.

Importantly, from the systems perspective used in this thesis, the time horizon for analysis of a system cannot be overemphasised (see chapter 2.2.2). System dynamics analysis must reach far enough into the past to show how a problem may have started as well as the symptoms and, especially in the case of disaster, it should also go far enough into the future that it can show the delayed, indirect, unforeseen effects. This has been discussed extensively by systems thinkers such as Forrester (1999), Meadows (1998), Sterman (2000). Therefore, for future research and outside the scope of this thesis (see chapter 11 on future work), there is the need to investigate organisational recovery trajectories at longer times from the occurrence of the event and using multiple indicators (financial and non-financial) of organisational recovery. For instance after the Loma Prieta earthquake, studies at two separate times with the same organisations showed different results. Dahlhamer and Tierney (1998) found that the industry sector an organisation belonged to was not a statistically significant predictor of short-term business recovery whereas Webb et al. (2002) found that industry sector was indeed a strong predictor of long-term recovery.

Throughout this chapter, to better illustrate the results, there is a distinction made between short-term recovery and recovery in general.

7.2 Determinants of short-term recovery and their relative magnitudes

As outlined in chapters 4 and 6, industry and geographic sectors in the greater Christchurch area faced numerous challenges brought on by the Canterbury series of earthquakes. However, to make the findings from this study more useful and applicable, it is important to discern what factors caused organisations the most considerable challenge(s) and to what extent. In other words: what are the significant contributors to the short-term recovery of organisations and sectors in Canterbury after the 2010-2011 earthquakes? From research question 1 in chapter 2.10, three possible sets of contributors to organisational and sectoral recovery were identified: (1) the level of organisational resilience; (2) the pre-disaster characteristics within and around the organisations and sectors; and (3) the direct and indirect effects of the earthquakes to the organisations and sectors. These contributors are illustrated in Figure 7-1. A note on the contributor pre-disaster characteristics shown in Figure 7-1: the components are those from the literature that have been frequently listed as influencing organisational recovery (see chapter 2).

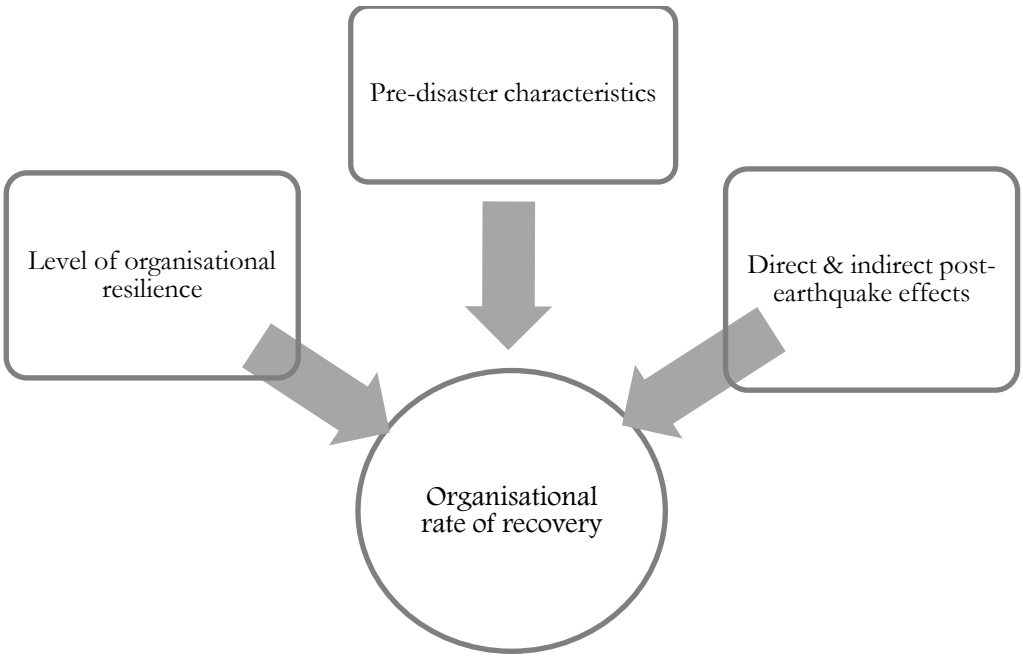


Figure 7-1: Contributors to organisational and sectoral recovery after the 2010 – 2011 Canterbury earthquakes

7.3 Short-term recovery rate coefficient (Short-term RRC)

It is useful to have a variable that can be used as a measure of the rate of organisational and sectoral short-term recovery to which the components can be compared and one that is usable across all sectors. As shown in section 2.3 the definition of recovery after disaster is contextual and subjective. In other organisational disaster studies, measures of recovery include the *time* taken for an organisation to recover (e.g. (Alesch et al., 2009)) or the self-report *post-disaster status* of the organisation (e.g. (Dietch & Corey, 2011)). Although using slightly different lenses, in both these studies, the measures of organisational recovery translated into the post-disaster revenue changes organisations experienced. Returning to or increase on pre-disaster levels of revenue is used as a marker for recovery. For instance, Sidel and Enrich (1998) show how, from the investor perspective, revenue growth for an organisation is more important than expenditure savings from cutting costs.

In interviews for this study, organisations were asked how they would measure recovery for their organisations. All the organisations queried reported that they would compare pre- and post-earthquake revenue (or budgets in the case of some governments departments) to analyse how well their organisation was performing after the Canterbury earthquakes. Like Sidel and Enrich (1998), Ailawadi et al (1999b) also write that organisations have a focus on financial performance indicators because they are easier to interpret.

As organisations had spoken of a financial measure, they were also asked about other possible financial measures of organisational recovery such as return on investment (ROI), profits and sales. Revenue has the advantage that it is reported for goods and services that have been delivered. Post-earthquake, revenue can also be directly compared to the organisation's expenditure. ROI has the disadvantage that the different organisations have various ways in which they value the assets that contribute to this metric. Also, ROI is based on historic data. Gunasekaran et al (2001) point to ROI decisions being based on the perspective at the time the ROI calculations were done. It can be concluded that for earthquake affected organisations in Canterbury, the ROI investments most likely did not allow for earthquake activity. Some of the same reasons for not using ROI as a post-earthquake gauge of organisational recovery apply to profit also. Bruns (1998) put forward that the historical information profit calculations are based on does not indicate future performance. As well, using profit as a measure for all organisations

is problematic because different organisations calculate and report their profits dissimilarly (Spathis, 2002). Additionally, reported profits are used by investors to make decisions about whether or not to invest in an organisation. Therefore, it is in the organisation's best interest to present a favourable profit position (Beaver & Demski, 1974; Hunton, Libby, & Mazza, 2006). When asked if sales would be an acceptable metric for measuring organisational rate of recovery after the earthquakes, organisations replied that sales figures would show customer orders but would not reflect that those orders had been honoured or that they had been paid for. It appears that among interviewed organisations, the idea of *sales* differs. On closer examination, it seems that the distinction is to do with the recorded amount of ordered goods and services as opposed to the payment for these goods and services.

Considering the different sectors involved in the study and their responses when asked how they would measure recovery, revenue was deemed the most suitable metric. Organisations thus characterised recovery as a return to pre-earthquake levels of revenue or better. Figure 7-2 illustrates how organisations visualised their recovery. The + and – signs in the figure indicate the post-earthquake direction of revenue change. Therefore, using revenue change data available from Survey 2, a short-term recovery rate coefficient (short-term RRC) was determined for each organisation. Organisations were asked about changes in revenue for two consecutive time periods. Period 1 was between 4 September 2010 and 22 February 2011. Period 2 was after 22 February 2011 up to September 2011. Each instance of revenue decrease was assigned a score of -1, each increase was +1 and no change in revenue was assigned a zero (0). Points for an individual organisation, for each time period, were added to give the organisational short-term RRC. The maximum short-term RRC value after Survey 2 is +2, an increase in revenue in each of the time periods, while the minimum short-term RRC value is -2 which corresponds to a decrease in revenue in each of the time periods. As with other metrics, the short-term RRC has limitations as well as advantages. A limit to using the short-term RRC, in this case, is that it asks about consecutive time periods in the chaotic short-term period after a disaster. The effects to organisations in this time period may not be a reflection of their ability to recover in the medium- to long-term. However, an advantage is that organisations can track the effects of disaster to the organisation using a measure they understand. Also, it is possible for organisations to use this short-term RRC information before a disaster happens. From analysis

of revenue change patterns, organisations can plan for and mitigate effects that manifest in the period immediately following a disaster event. For instance, organisations can take actions like ensuring availability and access of resources for a longer period after a disaster happens when revenue might be low.

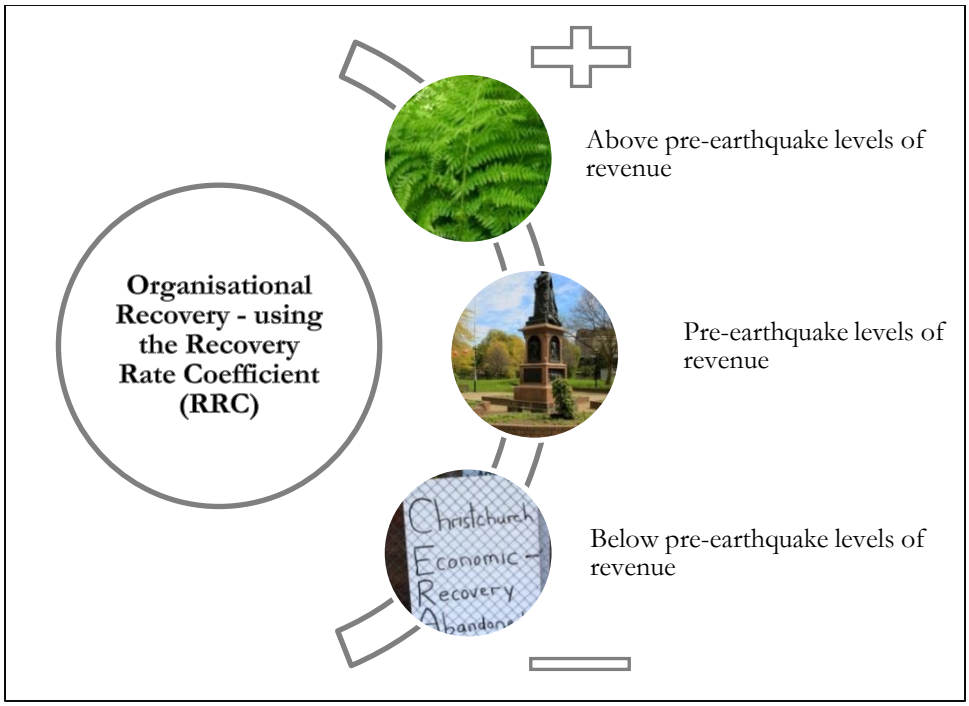


Figure 7-2: Organisational post-earthquake levels of recovery (using revenue changes) as defined by organisations and sectors after the Canterbury earthquakes

Organisations were not explicitly asked to compare revenue changes with those from the same period in the previous financial year or with changes from the time period immediately prior to the ones asked about. However, some of the respondents spoken to described that their usual revenue comparisons were year-on-year as that is how they normally analysed revenue changes. Some organisations further stated that this way of comparing revenue changes took in to consideration that revenue was different dependent on time of year. For instance, one hospitality organisation (selling beverages) reported that revenue always increased in the summer months while a retail organisation also pointed to an increase in revenue when people purchased camping equipment in preparation for summer holidays. Table 7-1 shows the percentage of organisations from each sector with specific RRC values after the 22 February 2011 earthquake.

Table 7-1: Short-term recovery rate coefficient (short-term RRC) by per cent of organisations in each sector after Survey 2

	Sectoral short-term recovery rate coefficient (short-term RRC) after Survey 2:				
	-2	**-1**	**0**	**1**	**2**
Building Suppliers	82%	0%	0%	9%	9%
Critical Infrastructure	13%	20%	33%	13%	20%
FMCG	21%	14%	14%	21%	29%
Hospitality	57%	0%	14%	0%	29%
ICT	13%	4%	50%	21%	13%
Trucking	33%	8%	33%	0%	25%
Christchurch CBD	80%	7%	0%	0%	13%
Kaiapoi Town Centre	23%	23%	31%	15%	8%
Lyttelton Town Centre	38%	19%	38%	3%	3%
Entire Sample	36%	12%	28%	10%	14%

More organisations (36%) had an RRC of -2 than any other value. Also, more organisations (82%) from the building suppliers sector had an RRC of -2 than from any other sector. This was followed by Christchurch CBD (80%) and hospitality (57%). In contrasting fortunes 29% of organisations from the hospitality sector had an RRC of +2. These hospitality organisations are the ones that re-opened a few days to a few weeks after the earthquakes. They reported that part of the increased custom resulted from other hospitality establishments being closed.

Table 7-2 shows the sectoral RRC values after Survey 3. Organisations were asked to detail their change in revenue for the period after September 2011 to the time they took the survey in March to May of 2012. The RRC for the different industry sectors still showed a general pattern of decrease in revenue.

Table 7-2: Short-term recovery rate coefficient (RRC) by per cent of organisations in each sector after Survey 3

	Sectoral short-term recovery rate coefficient (RRC) after Survey 3:						
	-3	**-2**	**-1**	**0**	**1**	**2**	**3**
Building Suppliers	83%	0%	0%	0%	0%	0%	17%
Critical Infrastructure	14%	14%	29%	0%	14%	14%	14%
FMCG	25%	0%	0%	0%	25%	25%	25%
ICT	8%	0%	8%	33%	33%	17%	0%
Trucking	20%	0%	40%	20%	0%	0%	20%
Christchurch CBD	60%	0%	40%	0%	0%	0%	0%
Kaiapoi Town Centre	20%	0%	40%	0%	20%	20%	0%
Lyttelton Town Centre	11%	11%	22%	22%	22%	0%	11%
Entire Sample	25%	4%	22%	13%	18%	9%	9%

The RRC values used for analysis in this section of the thesis are those from Survey 2. This is for a number of reasons. First, Survey 2 included questions, not asked in Surveys 1 and 3, that are used as components to the contributors discussed later in this chapter. These components of recovery are correlated against revenue change data from the same survey, i.e. for the same time period after the earthquakes. Survey 2 also had participating organisations, from Lyttelton, that were not included in Survey 1 and Survey 2 also had more organisations participating than Survey 3. Again, it should be noted that the RRC only has data from the response and short-term recovery phase.

7.4 Contributors to sectoral and organisational short-term recovery

The short-term RRC was used as the dependent variable for a uniform measure of post-earthquake outcomes while level of organisational resilience, pre-earthquake effects as well as direct and indirect effects after the earthquakes were the independent variables. These independent variables have been called the contributors to the organisation's rate of recovery and are plotted in this chapter for the short-term recovery phase. These contributors of recovery are aggregated measures of individual components (variables) that are representative of the

contributors. From Surveys 1 and 2, different components representing pre-earthquake characteristics and direct and indirect effects were assigned to the different contributors. For example, an organisation's cash flow situation prior to disaster is one of the elements considered a component of the contributor pre-earthquake effects. The planning and adaptive capacity factors make-up the contributor organisational resilience. Analysis of the indicators of recovery shows that organisations leaned in the direction of one of the two factors of organisational resilience. This is one of the reasons for the use of the factors of resilience as the components of the contributor organisational resilience. As well, for reasons of space and to avoid repetition, the individual indicators of recovery are discussed at length in chapter 10.

Details of the contributors to organisational recovery rates and their components are in Figure 7-3. The selection of components for each contributor was done based on a review of the literature (see chapter 2) and in consideration of the geographical context of the research and the sectors involved. For example, organisational closure for both the 4 September 2010 and 22 February 2011 earthquakes was included as the earthquakes caused different levels of damage and in different locations.

The components of recovery can be thought of as indicators of recovery. Freudenberg (2003) writes that indicators are measures, qualitative or quantitative, formulated from factual observation and that act to better explain and convey complex circumstances. Nardo et al (2005) add that using multiple indicators, or in this case components, brings together information of different concepts that cannot be properly represented by an individual indicator or variable. Additionally Freudenberg explains that indicators show the relative position of what is being measured and when evaluated over time can show the magnitude and direction of change.

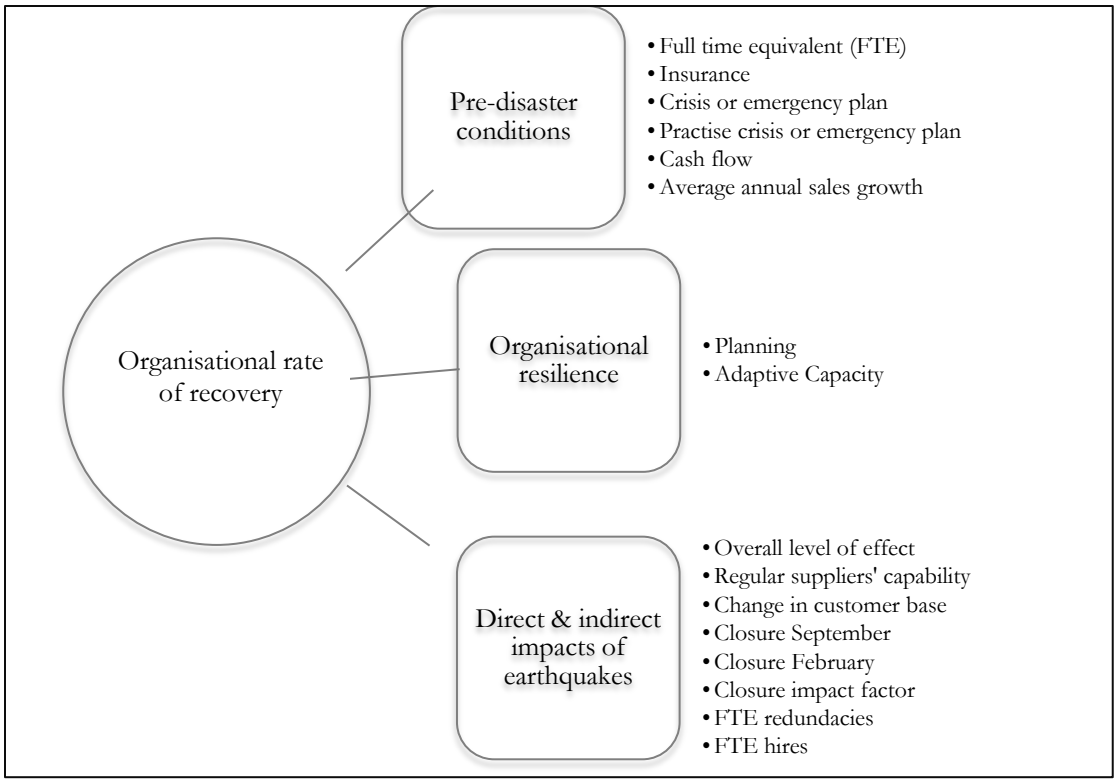


Figure 7-3: Organisational rate of recovery and contributors to organisational and sectoral recovery[42]

Weighting of the components and contributors of recovery[43]

For the purposes of this thesis, the weights of the contributors of recovery are taken to be equal. This is because weighted aggregation would imply that the weightings of the different components in the contributors are known. For the data in this study this is yet to be ascertained. Additionally, this method of data aggregation leads to the loss of resolution. For example on the pre-earthquake conditions contributor which has a total score of six: if one organisation had component scores of (1, 0, 0.5, 0.5, 0.8, and 0.2) while another had component scores of (0, 1, 0, 1, 0, and 1); both organisations would have a contributor score of three out of six. However, the weight of the contributing components varies and this is lost when the individual component scores are aggregated and added. In fact one of the aims of the study is to determine the influence of each contributor. Consequently, the weighted method of aggregation for the contributors will not be used at this stage.

[42] One Full time equivalent (FTE) equals 1 employee working full time. For closure impact factor items, see question 16 in appendix G.

[43] Appendix N contains alternative data analysis technqiues that were attempted but have not been used

7.4.1 Regression and correlation

Regression analysis is the name given to the family of techniques used for analysing and modelling multiple variables. It is the study of dependence between variables (Asuero, Sayago, & Gonzalez, 2006). Regression techniques are used when the focus is on the relationship between a dependent variable and one or more independent variables. Regression analysis aids in the understanding of the relationship and the strength of the relationship between two variables. The strength of the relationship between two variables in a statistical population is called the effect size. In analysing the interdependence between variables, their correlation values are used (Asuero et al., 2006). For regression, the short-term recovery rate coefficient (short-term RRC) will be plotted against all the component values and the *coefficients of determination* (R^2) for each relationship will be used to show the strength of the relationship. The computations will be based on the entire sample in the study as opposed to at the sectoral level. This is because the overall sample size is larger than the individual sector sample sizes. R^2 is derived from the regression equation whose standard form is $Y = a + bX$ where

- → Y is the estimated score for the dependent variable;
- → X is the score for the independent variable;
- → b is the slope of the regression line; and
- → a is the intercept, or the point on the vertical axis where the regression line crosses the vertical y-axis.

The regression equation states the mathematical relationship between the two variables being investigated. The regression line on a graph can be used to predict the value of the dependent variable for any value of the independent variable. The differences between these predicted values and how far the dependent variables are from the regression line are called residuals. A graphical plot of the residuals also shows how well the estimated regression line, R^2 value, fits the data.

R^2 is the square of the correlation coefficient (r) and is a value between 0 and 1: 0 indicates no relationship and 1 indicates a very strong relationship between variables. In the case of two

variables, R^2 is the proportion of total variation in one variable that is explained by the other variable (Cornell & Berger, 1987; Jensen, 1980).

In addition to the plotting of the short-term recovery rate coefficient against each of the components of recovery, the correlation relationships between these variables are also investigated to determine their influence on organisational recovery. The most common measure of correlation is the Pearson Product Moment Correlation (shortened to Pearson's correlation or Pearson's r) (Lee Rodgers & Nicewander, 1988). Pearson's r reflects the degree of linear relationship between two variables and ranges from +1 to -1. A correlation of +1 means that there is a perfect positive linear relationship between variables. Pearson's r does not distinguish between dependent and independent variables and, unlike the R^2 value, does not indicate the slope of the line in the relationship between two variables and. Cohen (2001) offers guidelines on interpretation of Pearson's r values. These are shown in Table 7-3.

Table 7-3: Guidelines on interpretation of Pearson's r values

Strength of correlation	Direction of correlation - Positive	Direction of correlation - Negative
Strong	0.5 to 1.0	−1.0 to −0.5
Medium	0.3 to 0.5	−0.5 to −0.3
Small	0.1 to 0.3	−0.3 to −0.1
None	0.0 to 0.09	−0.09 to 0.0

Sample size

Cornell and Berger (1987) note that one of the factors affecting the value of R^2 is the size of the sample. Minitab Inc., developer of the statistical software package Minitab, also has similar findings. They caution that 40 is an ideal sample size in case the relationship between X and Y is not very strong (Minitab Inc, 2012). If a small sample size is used (e.g. less than 15), then the relationship between X and Y may not be detected. Minitab also goes on to state that a more exact R^2 value is obtained with larger samples of at least 40. Furthermore, Tabachnik and Fiddell (2001) recommend that a sample size for regression should be the larger of either the number of (independent variables x 8 + 50) or the number of (independent variables + 105). Using this as a guideline, simple linear regression in this study would require a sample of 106 cases. The study Survey 2 results have at least 150 cases.

7.4.2 **Overview**

Each of the components of recovery is plotted directly against the short-term RRC and the R^2 value computed. This is depicted in the scatter diagrams in Figures 7-5 to 7-21. Scatter diagrams are usually a first step in exploring relationships between variables and are useful because they convey information of the variables visually (Weihs, 1993). Some of the scatter diagrams are converted into and presented as density plots for better illustration. This is in cases where multiple data plots are in the same position.

As all the components are individually plotted against a common variable (the short-term RRC), it is possible to compare the individual R^2 values (Exner & Zvara, 1999; Kvalseth, 1985). Therefore, using the percentage of variance accounted for, the significant contributors of short-term recovery after the Canterbury earthquakes are described below.

7.4.3 **Pre-earthquake characteristics as a contributor**

From Figure 7-3, there are six contributors for the pre-earthquake conditions contributor. The R^2 values from the pre-earthquake components plotted against the short-term RRC are presented here in Figures 7-4 to 7-18. Figures 7-4 to 7-6 and 7-18 show R^2 values very close to 0 which denotes a very weak relationship between those pre-earthquake components and the organisation's short-term RRC. Figure 7-9 shows a marginally higher effect size for organisational cash flow against organisational short-term RRC. All the R^2 values for the pre-earthquake components are shown in Table 7-4.

As all but one of the organisations in this study had insurance and there are more than two sectoral groupings, the Kruskal-Wallis test (a non-parametric analysis of variance, ANOVA, test) was used to statistically compare the different groups. This is instead of plotting organisational insurance against the short-term RRC. There was no statistically significant difference between the different the sectors ($H(8) = 3.229$, $P = 0.919$) for the insurance contributor.

Analysis of the components making up the pre-earthquake contributor and on the strength R^2 values, cash flow is the more significant contributor (R^2 value of 0.051). Table 7-4 contains the correlation values of the pre-earthquake components and the recovery rate coefficient. As expected, there is a positive correlation ($r=.397$, $p<.01$) between organisation's having crisis or

emergency plans and the practising of the plans. Interestingly, there is a negative correlation (r=-.226, p<.01) between the recovery rate coefficient and organisational cash flow and a negative correlation (r=-.264, p<.01) between organisational cash flow and the number of full-time equivalent staff. There is also a negative correlation (r=-.265, p<.01) between the size of the organisation and the practising of crisis plans. This is in contrast to findings in the disaster literature on the size of the organisation influencing the practising of crisis plans. From the organisations in this study, the critical infrastructure and FMCG organisations were more likely to have crisis or emergency plans. However, even within these sectors, the numbers of full-time equivalent staff varied across the organisations. The critical infrastructure sector organisations reported FTE staff from 20 to 1500 while FMCG organisations reported FTE staff from 6.5 to 1022.

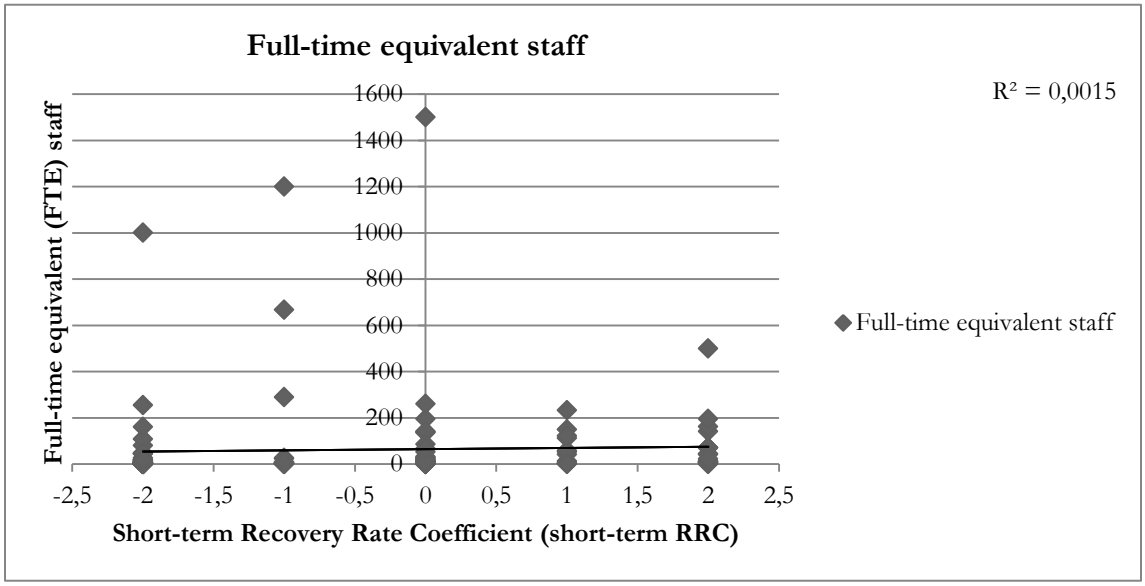


Figure 7-4: Full-time equivalent staff (FTE) plotted against short-term recovery rate coefficient (short-term RRC)

Crisis/emergency or business continuity plan (R^2 = 0.00721)

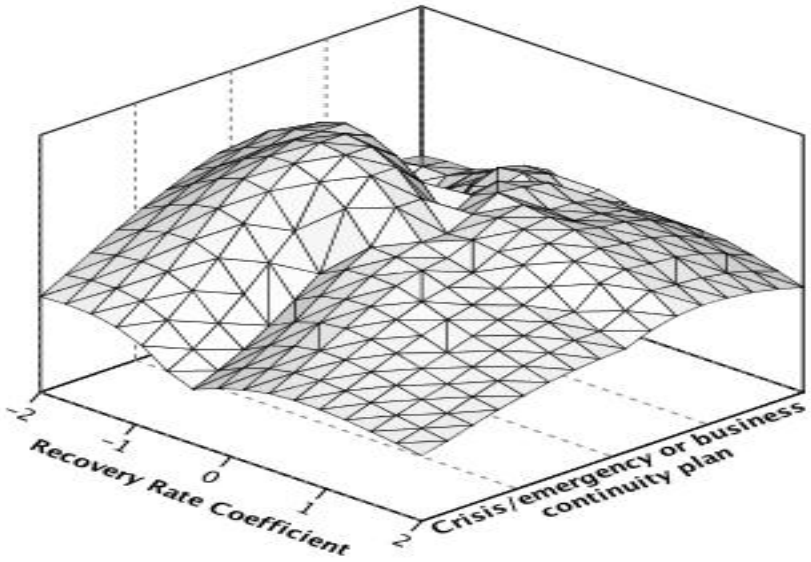


Figure 7-5: Existence of organisational crisis or emergency plan plotted against short-term recovery rate coefficient (short-term RRC)

Prior to 4 September 2010 - practised emergency response (R^2 = 0.00148)

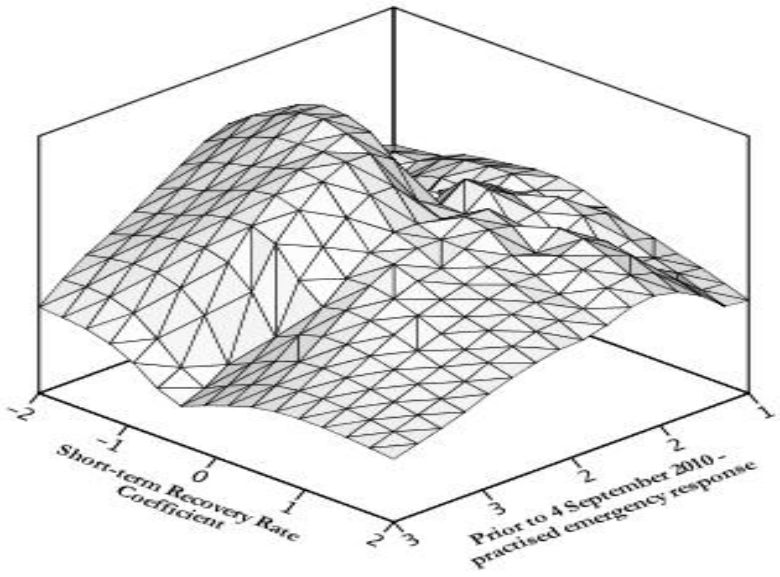


Figure 7-6: Practise of organisational crisis/emergency plan plotted against short-term recovery rate coefficient (short-term RRC)

Organisational cash flow (R^2 = 0.05099)

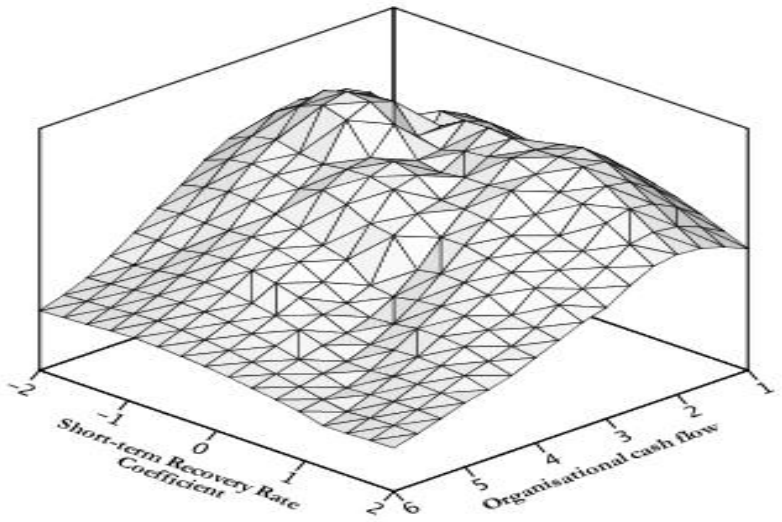


Figure 7-7: Organisational cash flow levels plotted against short-term recovery rate coefficient (short-term RRC)

Average annual sales growth/organisation's income budget (R^2 = 6.4E-06)

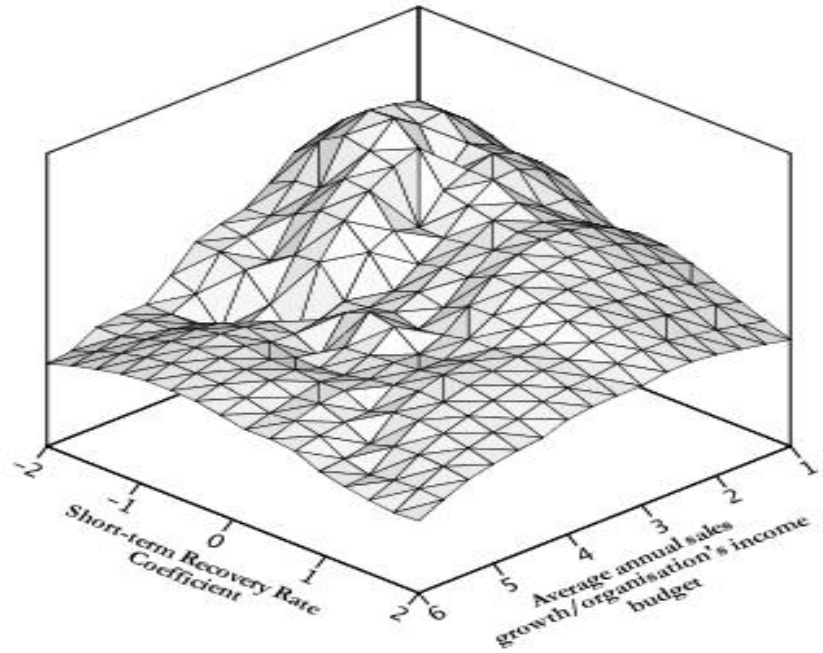


Figure 7-8: Organisational average annual sales growth or organisation's income budget plotted against short-term recovery rate coefficient (short-term RRC)

Table 7-4: R^2 values for pre-earthquake contributors and short-term recovery rate coefficient (short-term RRC)

Contributor	Component	R^2 value
Pre-disaster conditions	Cash flow	0.051
	Crisis or emergency plan	0.0072
	Practise crisis	0.0015
	Insurance	0.0007
	FTE	0.0005
	Average annual sales growth	6.00E-06

Table 7-5: Correlation (r) values for pre-earthquake components and short-term recovery rate coefficient (short-term RRC)

	Short-term Recovery Rate Coefficient	Organisational cash flow	Crisis/emergency or business continuity plan	Prior to 4 September 2010 - practised emergency response	Insurance	Full-time equivalent staff	Average annual sales growth/organisation's income budget
Short-term Recovery Rate Coefficient	1						
Organisational cash flow	-.226**	1	.184*	.099	-.039	-.264**	
Crisis/emergency or business continuity plan	-.085		1		-.040	-.277**	
Prior to 4 September 2010 - practised emergency response	-.038		.397**	1	-.052	-.265**	
Insurance	-.027				1	.028	
Full-time equivalent staff	.022					1	
Average annual sales growth/organisation's income budget	.003	.192*	.138	.031	.054	-.069	1

***. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).*

7.4.4 The Benchmark Resilience Tool (BRT-53) organisational resilience score as a contributor to short-term recovery

After Survey 2, the organisational resilience scores determined after use of the Benchmark Resilience Tool (BRT-53) were in a narrower range across all sectors when compared to organisational resilience scores from Surveys 1 and 3. This means that after Survey 2 there were similar organisational resilience score profiles for organisations with short-term RRC values ranging from -2 to +2. The reasons for this might be three-fold. The first is that the BRT, which uses self-report responses, was developed during peacetime and not in the aftermath of a disaster. From a systems perspective, system elements and behaviour would be different pre- and post-disaster. Similarly, Harter et el (2006) demonstrate that disaster events affect responses for ongoing surveys. Post-earthquake, it is likely that respondents were more sensitive to some of the questions as a result of the earthquakes. The second reason is to do with the design of the questions which do not allow for enough variance among respondents. Lastly, the organisational resilience scores in the short-term may be an artefact of the chaotic nature of the short-term recovery phase.

Figures 7-9 to 7-11 show the strength of the relationship between the factors of organisational resilience and the overall organisational resilience score when plotted against the short-term recovery rate coefficient (short-term RRC). Analysis of the figures and of the R^2 values (Table 7-6) shows that there is a weak relationship between the organisations' levels of resilience and the rate of recovery (measured using the short-term RRC). Furthermore, Table 7-7 shows that there is no statistical correlation between the level of organisational resilience and short-term RRC.

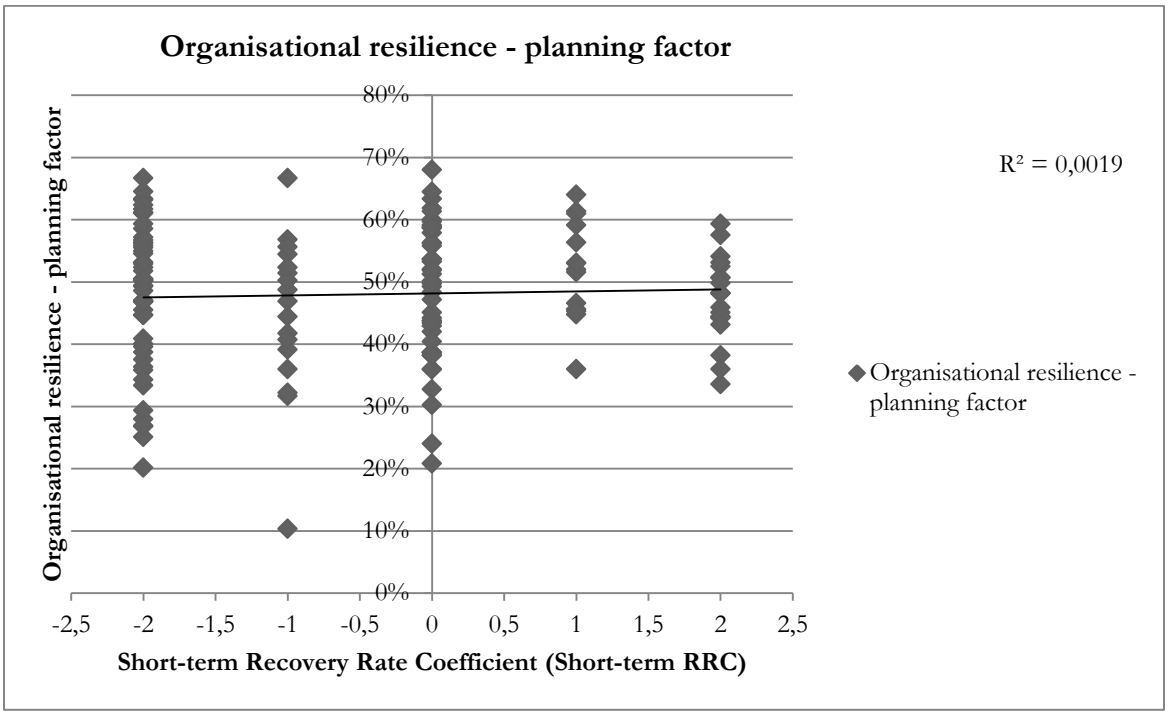


Figure 7-9: Organisational resilience planning factor plotted against short-term recovery rate coefficient (short-term RRC)

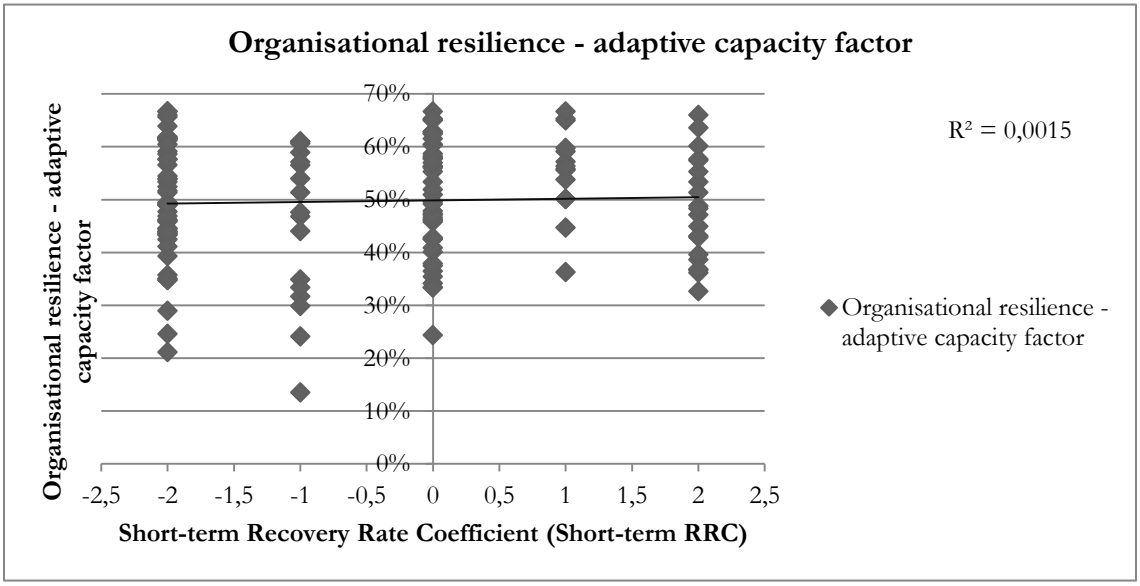


Figure 7-10: Organisational resilience adaptive capacity factor plotted against short-term recovery rate coefficient (short-term RRC)

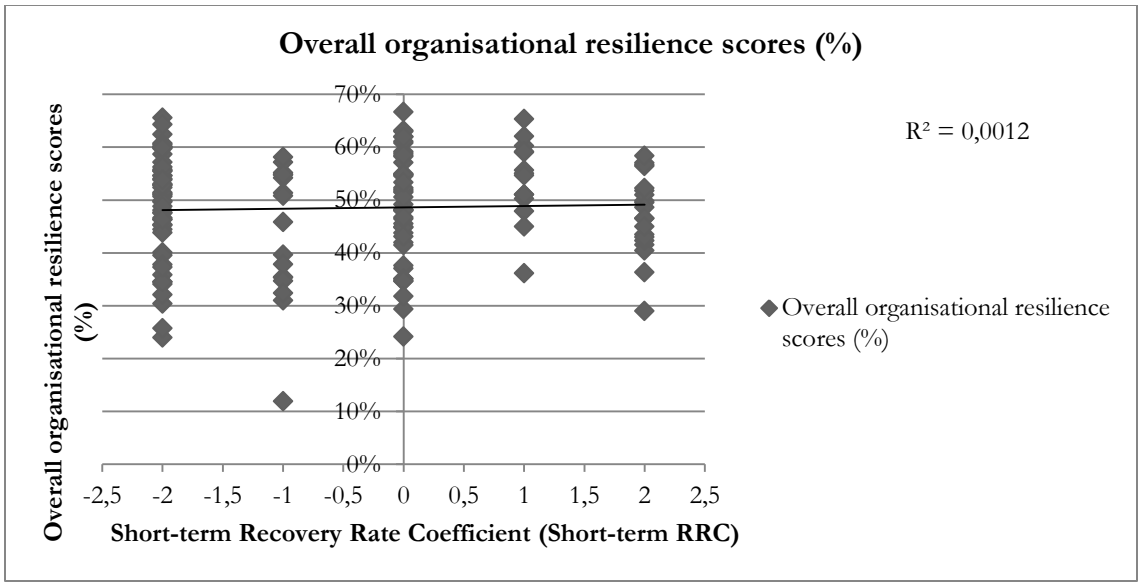


Figure 7-11: Organisational average resilience scores plotted against short-term recovery rate coefficient (short-term RRC)

Table 7-6: R2 values for resilience contributors and short-term recovery rate coefficient (short-term RRC)

Contributor	Component	R^2 value
Organisational resilience	Planning factor	0.0019
	Adaptive capacity factor	0.0015
	Overall	0.0012

Table 7-7: Correlation (r) values for resilience components and short-term recovery rate coefficient (short-term RRC)

	Short-term Recovery Rate Coefficient	Organisational resilience - planning factor	Organisational resilience - adaptive capacity factor	Overall organisational resilience scores (%)
Short-term Recovery Rate Coefficient (RRC)	1			
Organisational resilience - planning factor	.053	1		
Organisational resilience - adaptive capacity factor	.053	**.652****	1	
Overall organisational resilience scores (%)	.045	**.906****	**.912****	1

***. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).*

7.4.5 Direct and indirect earthquake effects

In the disaster literature, several authors (see e.g. (Alesch et al., 2009; Dietch & Corey, 2011; Holling, 1973; Kroll, 1991; Rose et al., 1997)) have shown how the effects of disaster can cause organisational disruption and closure, resulting in revenue losses. As shown in Figure 7-3, the third contributor of recovery being investigated is the direct and indirect effects of the earthquakes. In Survey 2, organisations were presented with a list of potentially disruptive factors and asked to detail which factors had caused the most disruption to their operations and to what degree, as well as what factors contributed to their organisation closing (for any period of time). The survey response options provided, for factors causing disruption or closure, are in a copy of Survey 2 contained in appendix L and are presented on their own in appendix G.

From Chapter 5 (Tables 5-16 to 5-19), it is shown to what extent each sector was affected by disruption to utilities and non-utilities as well as what contributed to organisational closure after the 22 February 2011 earthquake. Also shown in Tables 5-16 to 5-19 are the factors, for each sector, that were most disruptive. The individual organisation scores for the level of effect and for the closure impact factor are correlated against each other, against the recovery rate coefficient as well as against the individual resilience scores for each organisation. Table 7-9 contains the correlations.

Figures 7-12 to 7-19 show the plots of the direct and indirect effects components against the short-term recovery rate coefficient (RRC). The strength of this relationship is indicated by the value of R^2. The maximum value for R^2 is 1 and the closer the computed R^2 value is to 1, the stronger the relationship between the variable being investigated. In Figure 7-12, the R^2 value for level of effect (non-utility and utility) against short-term RRC is 0.037. This shows a weak relationship between the two variables. However, the level of effect and the short-term RRC have a medium strength negative correlation ($r=-.259$, $p<.01$) between them (Table 7-8). The negative correlation means that as the short-term recovery rate coefficient (short-term RRC) increases, the level of effect decreases. In other words, organisations that reported more damage or disruption were more likely to suffer revenue losses and vice versa.

The closure impact factor in Figure 7-17 was arrived at by assigning a value of 1 to each reason for closure and adding all the *1s* for each organisation (see Table 5-15 in chapter 5). The R^2 value

is 0.0774. The closure impact factor after 22 February 2011 correlates positively with the level of effect (r=.412, p<.01). Organisations with more reasons leading to closure reported a higher level of effect from disruptive factors such as to utilities.

Organisations in the study were also asked their operating hours in the period after both the 4 September 2010 and 22 February 2011 earthquakes. The alternatives ranged from *closed permanently* to *open but operated longer hours* (see Table 5-11). In the disaster literature, findings point to the duration of closure of an organisation being linked to their rate of recovery (Alesch et al., 2009). Some of the reasons ascribed to this include the non-return of customers or reduced cash flow after the resumption of organisational operations. The R^2 value is 0.0747 for 4 September 2010 and 0.0742 for 22 February 2011. Of interest is the strong negative correlation between the closure impact factor and organisational operating hours after both the 4 September 2010 (r=-.509, p<.01) and 22 February 2011 (r=-.594, p<.01) earthquakes. Organisations reporting more reasons contributing to closure operated shorter hours.

These findings in relation to organisations in Canterbury are similar to those in other disaster studies such as Chang's (2010) for the 1995 earthquake in Kobe and Webb et al's (2002) focused on the Loma Prieta earthquake and Hurricane Andrew.

The organisational operating hours for after both the 4 September 2010 and 22 February 2011 events show a strong positive correlation (r=.643, p<.01) with each other. After both earthquakes, the sectors reporting working longer than usual hours (see Table 5-11) were critical infrastructure and trucking. From case study and interview data, both sectors pointed to an increase in demand for their goods and services especially after the 22 February 2011 earthquake. Additionally, for both 4 September 2010 (r=-.251, p<.01) and 22 February 2011 (r=-.227, p<.01) earthquakes, Table 7-9 shows that organisational operating hours correlate negatively with the level of effect. Organisations that reported less damage and disruption were more likely to report a positive revenue change. Also, organisational operating hours exhibit a weak positive correlation with the recovery rate coefficient: (r=.273, p<.01) for 4 September 2010 and (r=.272, p<.01) for 22 February 2011 earthquakes.

Of the direct and indirect earthquake effect components, if using the R^2 value, change in customer base accounts for the larger percentage of variance (Figure 7-14). R^2 is 0.1799. A

change in customer base could be interpreted in a number of ways. The first is customers leaving or not returning to a disaster area (e.g. after Hurricane Katrina) or second, the altered needs of customers for the goods and services provided by an organisation (e.g. see (Tierney & Webb, 2001)). Corey and Dietch (2011) also report organisational recovery being affected by a change in customer numbers. Table 7-9 shows a positive correlation (r=.424, p<.01) between the change in customer base and recovery rate coefficient (RRC): organisations that experienced increased customer numbers showed positive revenue changes.

Neither FTE redundancies nor hires has a strong R^2 value. However, from Table 7-9, there is a weak correlation between the recovery rate coefficient (RRC) and the number of FTE hired (r=.202, p<.05) and made redundant (r=-.181, p<.05) after the 22 February 2011 earthquake. So organisations that had revenue increases were more likely to hire staff than make them redundant. This is supported by reports from sectors reporting increased workloads also taking on more staff (see section 5.2).

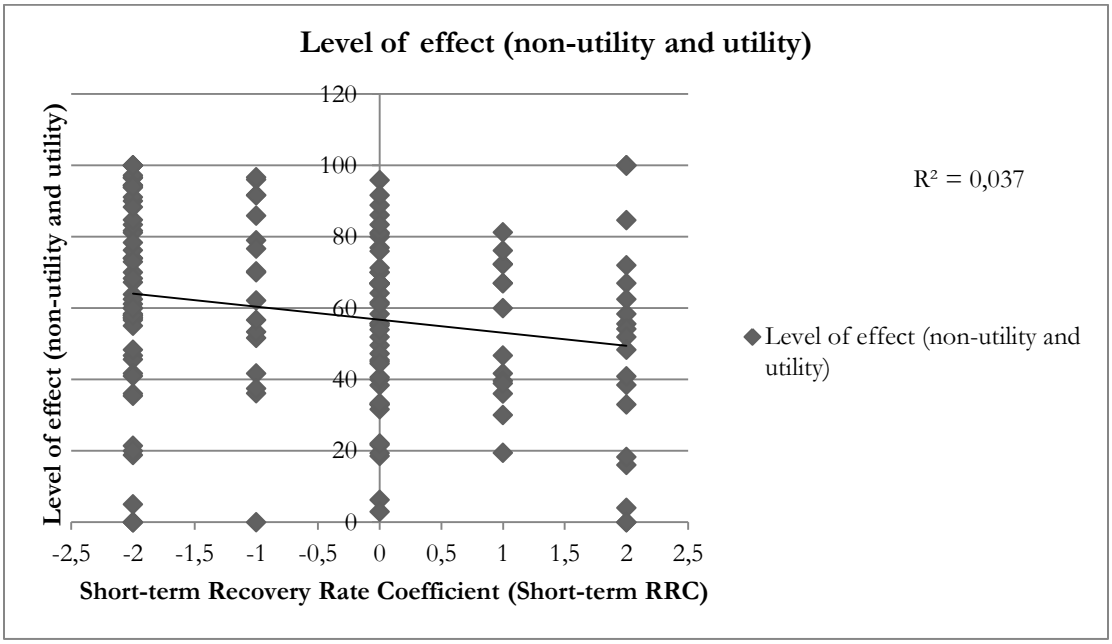


Figure 7-12: Level of effect after 22 February 2011 earthquake plotted against short-term recovery rate coefficient (short-term RRC)

Regular suppliers' capability after 4 September 2010 (R^2 = 0.00978)

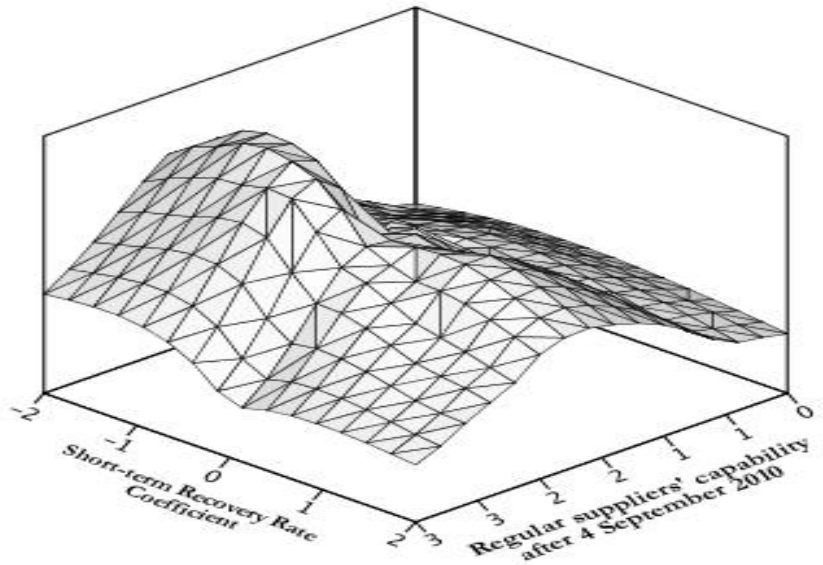


Figure 7-13: Regular suppliers' capability after 4 September 2010 earthquake plotted against short-term recovery rate coefficient (short-term RRC) (Lyttelton not included)

Change in customer base after 4 September 2010 (R^2 = 0.17993)

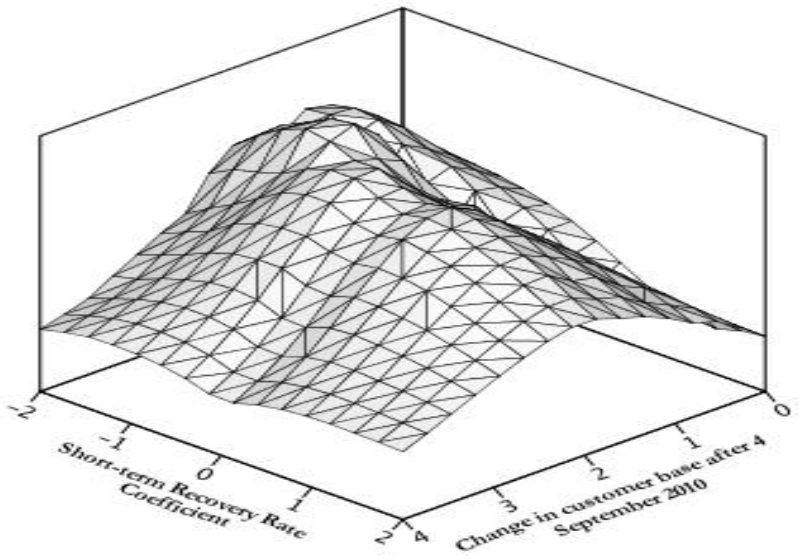


Figure 7-14: Change in customer base after 4 September 2010 earthquake plotted against short-term recovery rate coefficient (short-term RRC)

Organisational operating hours after 4 September 2010 (R^2 = 0.07469)

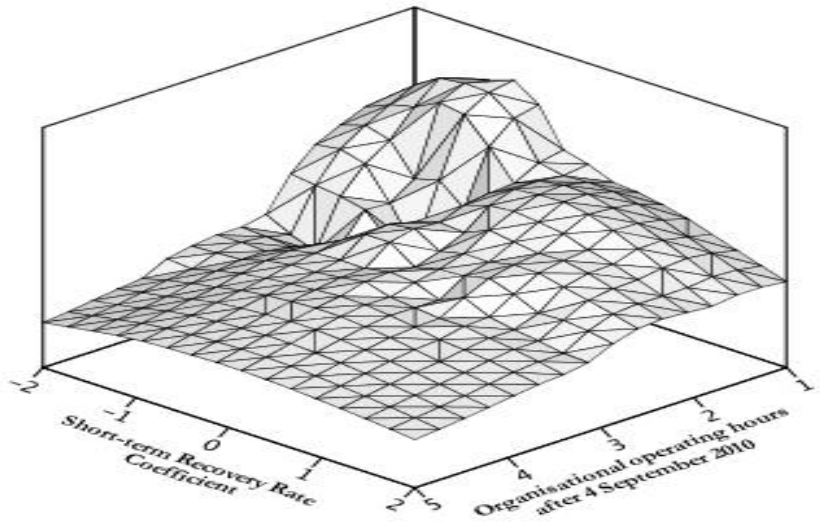


Figure 7-15: Organisational operating hours after 4 September 2010 earthquake plotted against short-term *recovery rate coefficient (*short-term *RRC)*

Organisational operating hours after 22 February 2011 (R^2 = 0.07422)

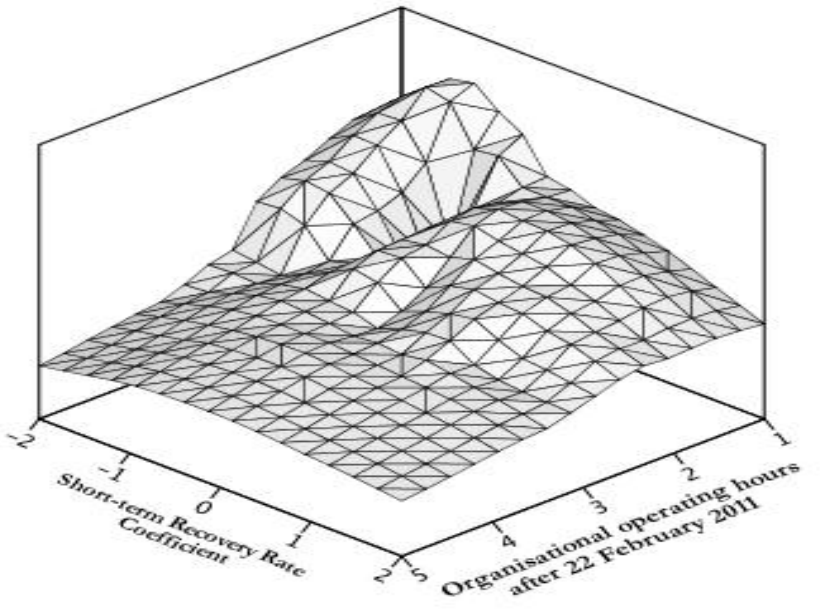


Figure 7-16: Organisational operating hours after 22 February 2011 earthquake plotted against short-term recovery rate coefficient (short-term RRC)

Closure impact factor after 22 February 2011 (R^2 = 0.07744)

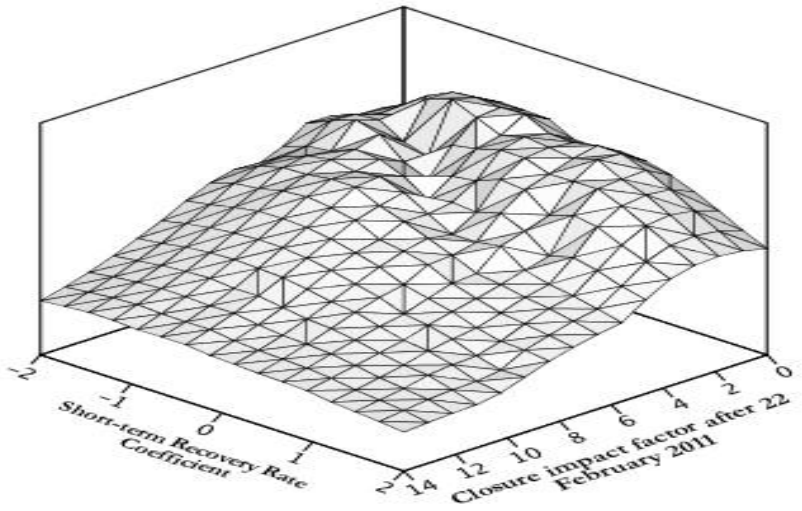


Figure 7-17: Organisational closure impact factor plotted against short-term recovery rate coefficient (short-term RRC)

Full-time equivalent (FTE) staff redundancies after 22 February 2011 (as % of FTE) (R^2 = 0.03293)

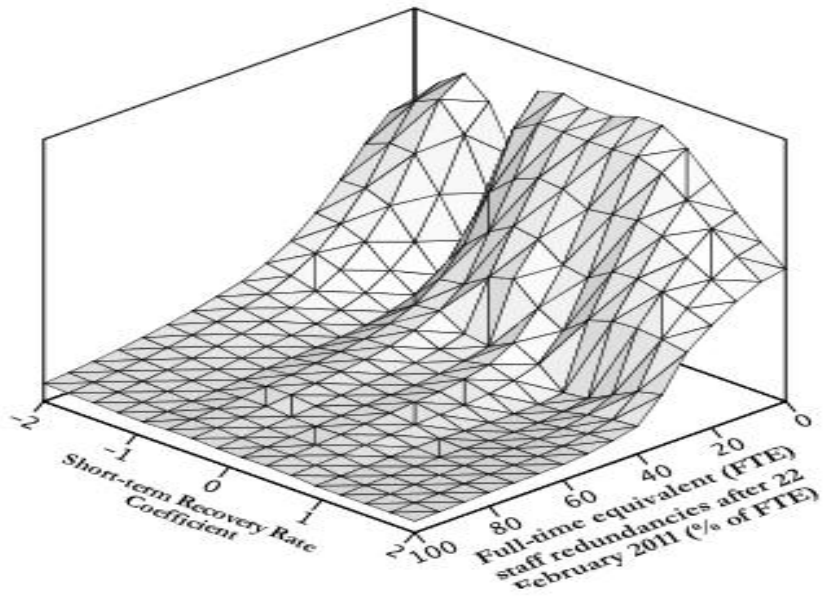


Figure 7-18: Organisational FTE redundancies after 22 February 2011 earthquake plotted against short-term recovery rate coefficient (short-term RRC)

Full-time equivalent (FTE) staff hires after 22 February 2011 (as % of FTE) (R^2 = 0.03961)

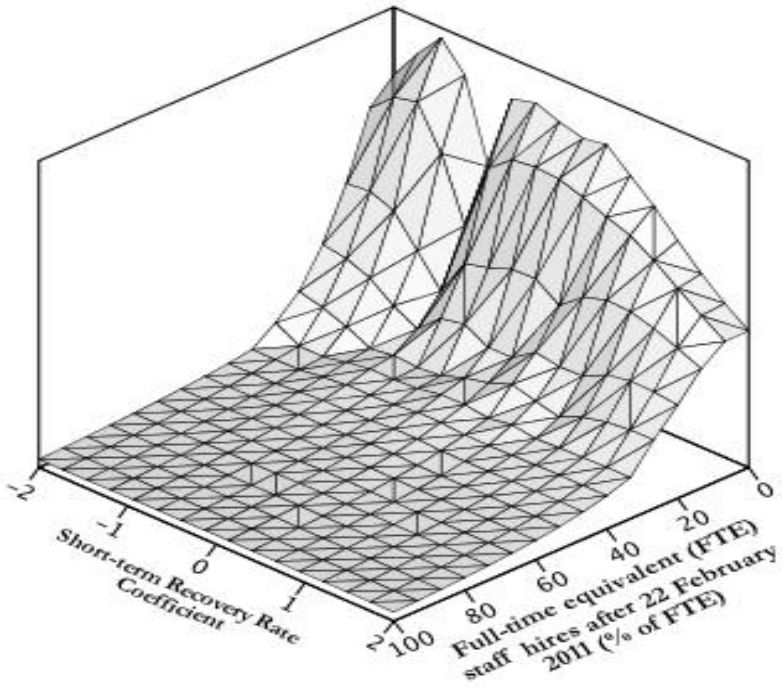


Figure 7-19: Organisational FTE hires (as per cent of FTE) after 22 February 2011 earthquake plotted against short-term recovery rate coefficient (short-term RRC)

Table 7-8: R2 values for direct and indirect earthquake effects and short-term recovery rate coefficient (short-term RRC)

Contributor	Component	R^2 value
Direct and indirect effects of the earthquake	Change in customer base after 4 September 2010	0.1799
	Closure impact factor after 22 February 2011	0.0774
	Closure after 4 September 2010	0.0747
	Closure after 22 February 2011	0.0742
	FTE hires after 22 February 2011	0.0396
	Overall level of effect (utility and non-utility)	0.037
	FTE redundancies after 22 February 2011	0.0329
	Regular suppliers' capability after 4 September 2010	0.0098

Table 7-9: Correlation (r) values for direct and indirect earthquake effects components and short-term recovery rate coefficient (short-term RRC)

	Short-term Recovery Rate Coefficient	Change in customer base after 4 September 2010	Closure impact factor after 22 February 2011	Organisational operating hours after 4 September 2010	Organisational operating hours after 22 February 2011	Full-time equivalent (FTE) staff hires after 22 February 2011	Level of effect (non-utility and utility)	Full-time equivalent (FTE) staff redundancies after 22 February 2011	Regular suppliers' capability after 4 September 2010
Short-term Recovery Rate Coefficient	1								
Change in customer base after 4 September 2010	**.424****	1					-.237*		.070
Closure impact factor after 22 February 2011	-.278**	-.130	1	**-.509****	**-.594****		**.412****		-.150
Closure (Organisational operating hours) after 4 September 2010	**.273****	**.222***		1			**-.251****		.029
Closure (Organisational operating hours) after 22 February 2011	.272**	.085		**.643****	1		**-.227****		.062
Full-time equivalent (FTE) staff hires after 22 February 2011	**.202***	.141	-.029	.069	.034	1	-.097	-.035	-.057
Overall level of effect (non-utility and utility)	**-.259****						1		
Full-time equivalent (FTE) staff redundancies after 22 February 2011	-.181*	-.016	.271**	-.178*	-.084		.142	1	-.002
Regular suppliers' capability after 4 September 2010	-.099						-.223*		1

***. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).*

7.4.6 Combined influence of components of short-term recovery

The previous section (7.3) showed the R^2 values for the different components when plotted against the short-term recovery rate coefficient (short-term RRC). Table 7-10 shows all the component R^2 values ordered from largest to smallest. Just over half of the R^2 values are under 0.01. Of the R^2 values above 0.01, the largest is the change in customer base with an R^2 value close to 0.18. In this study, this would make it the most significant component contributing to

organisational short-term recovery after the earthquakes in Canterbury, followed by the closure impact factor.

Table 7-10: All R^2 values for the components of short-term recovery

Contributor	Component	R^2 value
Direct and indirect effects of the earthquake	Change in customer base after 4 September 2010	0.1799
Direct and indirect effects of the earthquake	Closure impact factor after 22 February 2011	0.0774
Direct and indirect effects of the earthquake	Closure after 4 September 2010	0.0747
Direct and indirect effects of the earthquake	Closure after 22 February 2011	0.0742
Pre-disaster conditions	Cash flow	0.051
Direct and indirect effects of the earthquake	FTE hires after 22 February 2011	0.0396
Direct and indirect effects of the earthquake	Overall level of effect	0.037
Direct and indirect effects of the earthquake	FTE redundancies after 22 February 2011	0.0329
Direct and indirect effects of the earthquake	Regular suppliers' capability after 4 September 2010	0.0098
Pre-disaster conditions	Crisis or emergency plan	0.0072
Resilience	Planning	0.0019
Resilience	Adaptive capacity	0.0015
Pre-disaster conditions	Practise crisis	0.0015
Resilience	Overall	0.0012
Pre-disaster conditions	Insurance	0.0007
Pre-disaster conditions	FTE	0.0005
Pre-disaster conditions	Average annual sales growth	6.00E-06

The start of this chapter discussed the grouping of the components of recovery into three sets of contributors to recovery. Using the SPSS software package, multiple linear regression was performed on each group of components to generate the R^2 values for each contributor (Tables 7-11 to 7-13) as well as the normal plots (Figures 7-20 to 7-22). The normal plots used are p-p plots, or probability-probability plots, and are used to check the distribution of the residuals. The p-p plots for the pre-earthquake and direct and indirect effects contributors show a more linear distribution. For the resilience contributor (Table 7-12 and Figure 7-21), the residuals (the difference between the observed versus predicted values) are not symmetrically distributed

meaning the relationship between the plotted variables is non-linear. One variable does not predict the other.

Tables 7-11 to 7-13 show the R^2, adjusted R^2 and standard error of estimate values for all three contributors to short-term recovery. The adjusted R^2 value is a change to the R^2 value to compensate for the number of variables or the bias in a model when only R^2 is used (Heinzl & Mittlbock, 2003). This is because R^2 always increases when new variables are added whereas adjusted R^2 only increases if the added variable makes the model better. The standard error of estimate is a measure of the error in the prediction. The larger the value of the standard error of estimate, the more errors in the prediction.

Table 7-11: R^2 value for composite pre-earthquake contributor against short-term recovery rate coefficient (short-term RRC)

R^2 value for composite pre-earthquake contributor against short-term recovery rate coefficient (short-term RRC)			
R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
.205	.042	-.006	1.388

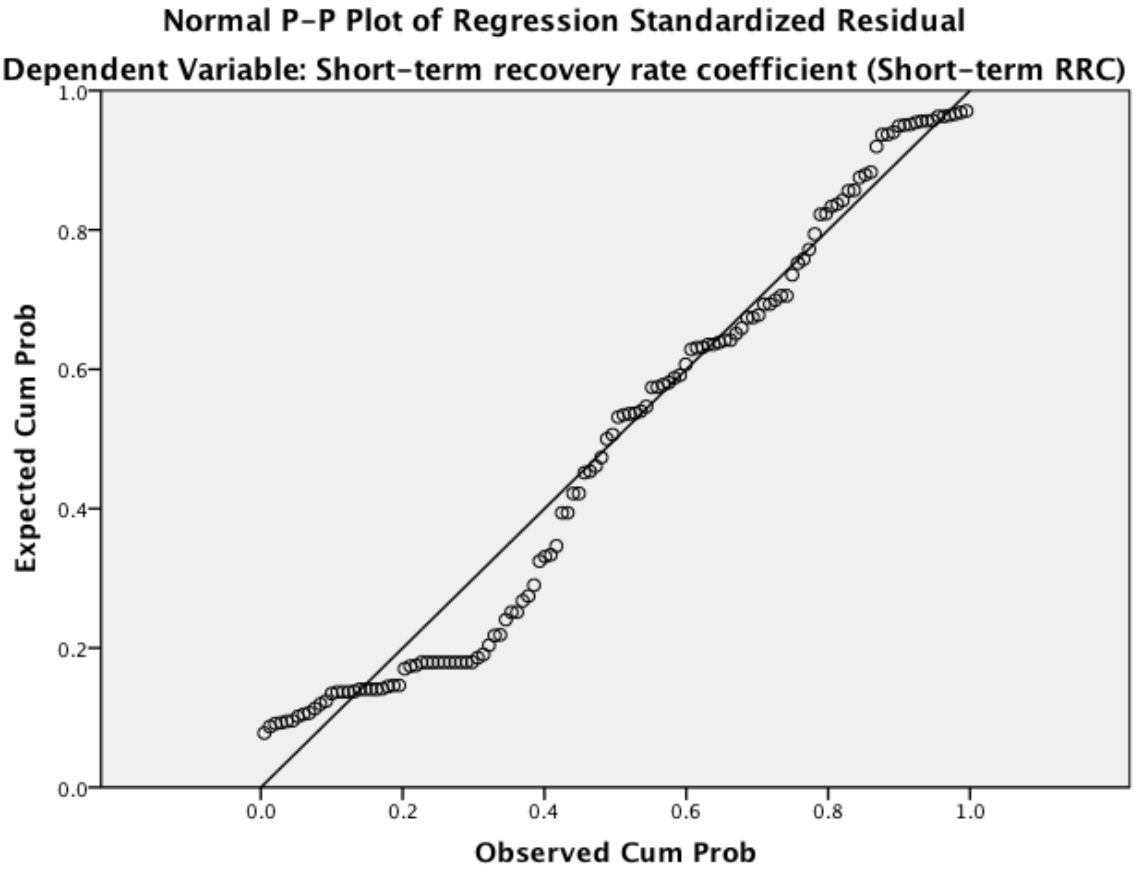


Figure 7-20: P-P plot for the pre-earthquake contributor

Table 7-12: R^2 value for composite resilience contributor against short-term recovery rate coefficient (short-term RRC)

R^2 value for composite resilience contributor against short-term recovery rate coefficient (short-term RRC)			
R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
.059*	.003	-.011	1.416

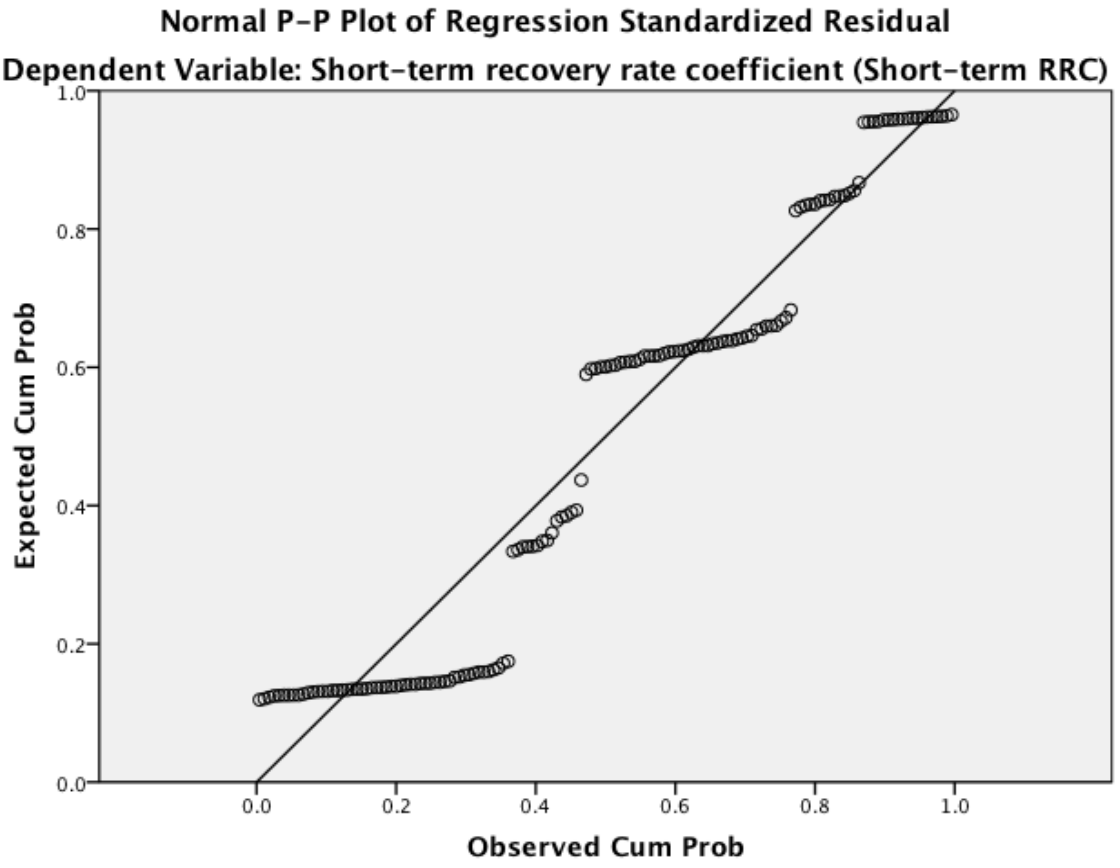


Figure 7-21: P-P plot of resilience contributor

Table 7-13: R^2 value for direct and indirect earthquake effects contributor plotted against short-term recovery rate coefficient (RRC)

R^2 value for direct and indirect earthquake effects contributor plotted against short-term recovery rate coefficient (RRC)			
R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
.544[a]	.296	.223	1.308

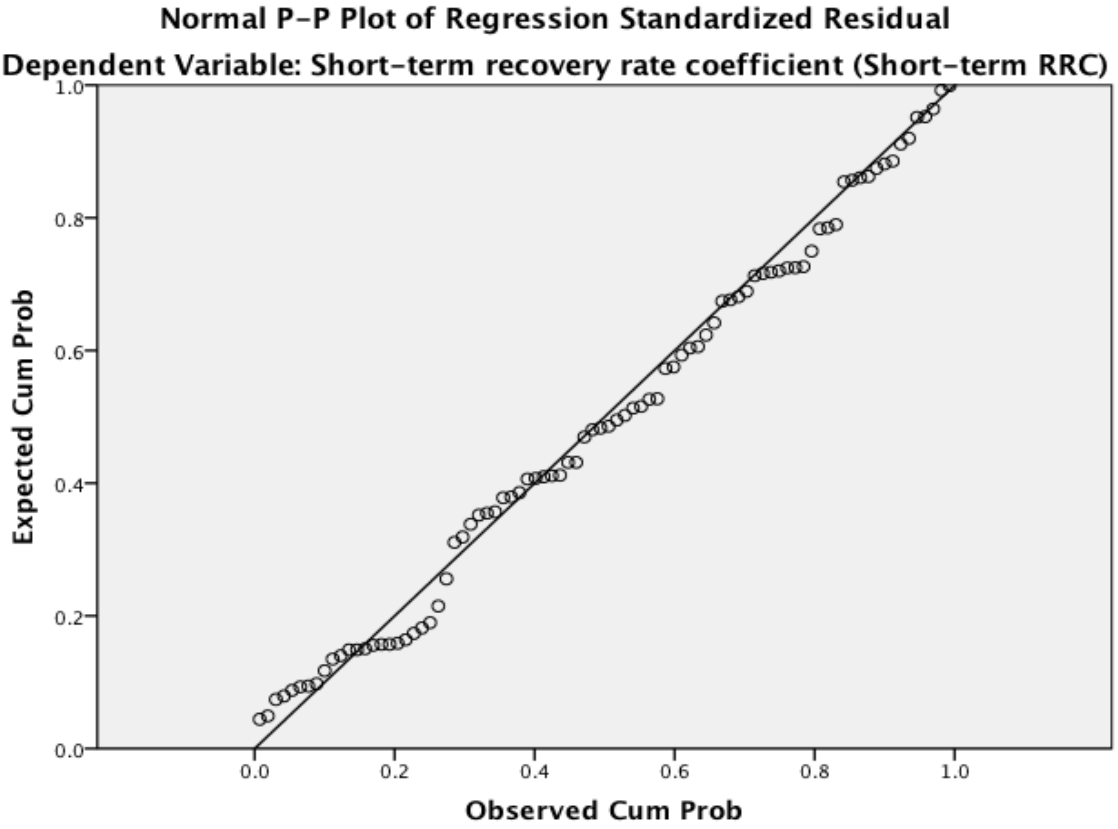


Figure 7-22: P-P plot of direct and indirect earthquake effects contributor

Comparing the three contributors to short-term recovery after the earthquakes in Canterbury, it can be seen that the direct and indirect earthquake effects contributor accounts for the larger percentage of variance, R^2 (.296) and adjusted R^2 (.223), when plotted against the short-term recovery rate coefficient (short-term RRC). Additionally, while the overall R^2 value for the pre-earthquake contributor accounts for a large percentage of variance, when all the component variables are taken into account, the adjusted R^2 value is low. This shows the extent to which change in customer base accounts for the variance. Lastly, the standard error of estimate for the three contributors to recovery is similar in this case.

7.5 Change in customer base as a significant contributor to organisational short-term recovery (from R^2 values)

The change in customer base plotted against the short-term RRC shows the largest R^2 value compared to the other components of recovery. This means that the change in customer base is

the most significant component contributing to organisational short-term recovery after the earthquakes in Canterbury. From the biggest challenges information and interview responses provided by organisations (see chapters 5.4 and 6); there are several elements that led to organisations facing customer issues after the 4 September 2010 and 22 February 2011 earthquakes. In interviews and from the biggest challenges data, it is clear that these customer issues were brought about by a number of elements. From organisational descriptions, customer issues translated in to a decrease in customer numbers, a decrease in how much customers spent as well as in a reduction in profit margins of certain products. This shows that the elements of post-disaster organisational recovery are related and influence each other.

Customer issues - decrease in customer numbers: organisations attributed reduced customer numbers to customers not wanting to access buildings they thought not safe, the perception that organisations were not operating because of cordons or nearby building damage as well as a reduction in foot traffic for location specific businesses. Two destination specific businesses from the Christchurch CBD reported that the distinctive nature of their goods and services were a help when customers started to spend money again. Alesch et al (2009) also found that reduced customer numbers after disaster affect an organisation's recovery. Some FMCG organisations narrated that a reason for diminished customer numbers was the relocation of customers. Similarly, Corey and Deitch (1987) write that the population dislocation in the Greater New Orleans area after Hurricane Katrina affected organisational recovery.

Customer issues - decrease in customer spending: from organisational reports, another feature of customer issues is customers spending less money post-earthquake. This is in line with Tierney (2007a) who writes that the uncertain economic conditions after disaster can affect customer spending especially on goods or services not deemed necessary after disaster. Some Canterbury hospitality organisations for example, detailed that the customers who did come in did not spend as much money as they did before the earthquakes. From accounts of building supplier organisations, the cancellation of pre-earthquake work also acted to decrease customer spending. This in turn affected organisational revenue, cash flow and ultimately recovery (more details in section 5.1). For some organisations, difficulties in delivering goods and services also led to customers spending less.

Customer issues - decrease in profit margins of products: some FMCG and Lyttelton organisations (more details in section 5.4) reported that they priced certain products lower than before the earthquakes in order to entice customers in to their stores as well as to get them to purchase more products. However, this meant a reduction in profit margins for these organisations; they also noted that such measures were only sustainable for the short-term.

7.6 Influence of geographic location on organisational short-term recovery

As three of the sectors were selected for this study based on their geographic location (see chapter 3), it is worth investigating the influence that geographic location had on organisational recovery. In Survey 2 organisations were asked whether or not they had relocated after the 4 September 2010 or the 22 February 2011 earthquakes. Eighty-nine per cent of organisations indicated that they had not relocated after the 4 September 2010 event while 69% did not relocate after the 22 February 2011 event. From chapter 5.2, 3% and 11% of all organisations reported closing permanently after the 4 September 2010 and 22 February 2011 earthquakes respectively. This means that, at the time of sampling for Survey 2, the majority of organisations were still operational and a large percentage of the sample had not changed location. This enables the investigation on the extent of geographic location as a contributor to organisational short-term recovery, measured using the short-term recovery rate coefficient (short-term RRC).

In Survey 2, organisations were asked to provide their physical location at the time of the earthquake as well as at the time of survey deployment. Investigation of organisational physical location and their short-term RRC values showed that the geographic location of the organisation was not a predictor of their change in revenue. For the three sample groups intentionally sampled for their location, the Christchurch CBD had 80% of organisations with a short-term RRC of -2 while Kaiapoi Town Centre had 23% and Lyttelton Town Centre had 38%. The CBD and town centres, because of pre-earthquake conditions (see chapters 5.4 and 6.7), suffered the greatest physical damage after the 4 September 2010 and 22 February 2011 earthquakes. None of the trucking organisations (33%) with short-term RRC values of -2 were located in the CBD or in any of the town centres. The building supplier organisations with short-term RRC values of -2 (82%) were not located within the four avenues that make up the

Christchurch CBD or in the Kaiapoi or Lyttelton Town Centres. Fifty per cent of ICT organisations had short-term RRC values of 0 while 43% reported short-term RRC values of +1 or better. Some of these organisations detailed that their organisation's premises were within the cordoned off Christchurch CBD.

This demonstrates that for the organisations affected by the Canterbury earthquakes, their location was only one variable in how they were affected. Their sector, i.e. the goods and services delivered, contributed to some of the impacts the organisations faced. Furthermore, as will be shown in chapter 8, there is an interaction of multiple variables in the way an organisation or sector is affected by disaster.

7.7 Signifiers of sectoral and organisational short-term recovery after the 2010-2011 Canterbury earthquakes

From the determinants of short-term recovery after the 2010 – 2011 Canterbury earthquakes and using information from the contributors as well as interview and survey data, it is possible to discern organisational and environmental features that may magnify or ameliorate the effects of disaster. These features, positive and negative, have been broadly categorised, do not apply to every sector and even within sectors do not apply to all organisations. Table 7-14 shows the features that organisations may take note of in trying to mitigate effects of disaster or in planning for the extent to which they may be affected. The checked boxes signify the factors that were important for each sector and contributed to recovery.

From Table 7-14, it is shown that some of the signifiers applied to all the sectors in this study. These are organisational adaptation, relationship with staff, capability of staff, availability of different kinds of resources and combined planning between the stakeholders in recovery such as organisations, local authorities and the community. The importance of combined planning also shows that in recovery, all stakeholders should be identified and involved (see chapter 9.6.1 and 9.7). Also, relationship and capability of staff aligns with organisations reporting that their biggest challenge across all three surveys deployed was staff wellbeing. This means that organisations should invest in their staff pre-disaster.

From Table 7-14, it is evident that for the different sectors, customers issues (discussed previously in this chapter) manifest via different signifiers; the post-disaster need for goods and

services, reliance on customer discretionary spending, the location of the organisation's premises and the ability of the organisation to deliver goods and services.

Table 7-14: Signifiers of post-disaster short-term recovery for organisations and sectors after the 2010-2011 earthquakes in Canterbury

	Building Suppliers	Critical Infrastructure	FMCG	Hospitality	ICT	Trucking	Christchurch CBD	Kaiapoi Town Centre	Lyttelton Town Centre
Post-disaster need for organisations goods and services	√	√	√	√	√	√			
Reliance on customer discretionary spending, location of customers	√		√	√	√				
Organisational assets in non-disaster resistant building							√	√	√
Occupation of buildings in close proximity to non-disaster resistant buildings							√	√	√
Little or no alternatives to critical infrastructure				√					
Diversity (product, location, customers)				√					
Organisational adaptation	√	√	√	√	√	√	√	√	√
Relationship with staff	√	√	√	√	√	√	√	√	√
Capability of staff	√	√	√	√	√	√	√	√	√
Availability of resources (e.g. financial, skilled labour, inputs for goods and services)	√	√	√	√	√	√	√	√	√
Destination or location specific business				√					
Mode of delivery for goods and services				√	√				
Planning for all hazards (involving organisations, local authorities and the community)	√	√	√	√	√	√	√	√	√

However, several crisis management and disaster recovery researchers such as Quarantelli (1993), Senge (2006), Simonovic (1982b), Mileti (2005), Alesch et al (2009) and Reason et al. (2006) have written on crises or disaster being complex phenomena with many interacting agents. From the work of these authors, and from the multiple interacting elements in the

Canterbury context, it is therefore possible to deduce that recovery from disaster should be from a holistic or integrated, i.e. systemic, perspective of these interconnected agents.

Consequently, the signifiers of recovery identified here should be used in the context of the organisation or the sector and the systems they belong to. The basic statistical techniques used in this chapter to highlight elements which affect recovery, while helpful, assume the laws of additivity and take the signifiers in isolation. From chapter 2, it was shown that cause and effect are not always linear or on a one-to-one ratio: the signifiers apply in different ways to different sectors. Also discussed in chapter 2 were the direct and indirect effects of disaster over time. A holistic, systems approach to investigating disaster recovery is more likely to show direct and indirect interactions. In light of these considerations and in addition to the information in Table 7-14, chapters 8 and 9 contain analysis on the system behaviours, aids and hindrances to recovery. The chapters also cover the points in a system where recovery may be influenced.

7.7.1 Time, recovery rate and short-term recovery trajectory

The path recovery takes for different organisations is dependent on a multitude of factors including location, industry sector, cash flow, type of goods and services the organisation provides, the overall recovery plan as well as other system effects such as the number of suppliers and how they each affect the organisation. From the above information, apart from the different combination of factors that affect the recovery of different organisations and industry sectors, it can be concluded that one of the factors affecting rate of recovery is time. Consequently, not only does recovery take a different course depending on organisation and sector but also the timeline for recovery is not uniform. This is illustrated in Figure 7-23

This research focused on the response and short-term recovery timeframe after disaster. It is acknowledged that the timespan of recovery extends beyond that. Prior to the earthquakes in Canterbury, organisations the world over experienced the global financial crisis. Some sectors, e.g. building suppliers, specifically reported that they were affected by the global financial crisis. For medium- to long-term recovery, a direction for future work is to determine how much influence the global financial crisis may have had on organisational recovery after the earthquakes. Also in relation to time in organisational recovery is the need for business owners to gauge when they are going to (re)open by also looking at the need for the goods and services

their organisation delivers, where their customers may have moved to or the availability of input for production of goods and services.

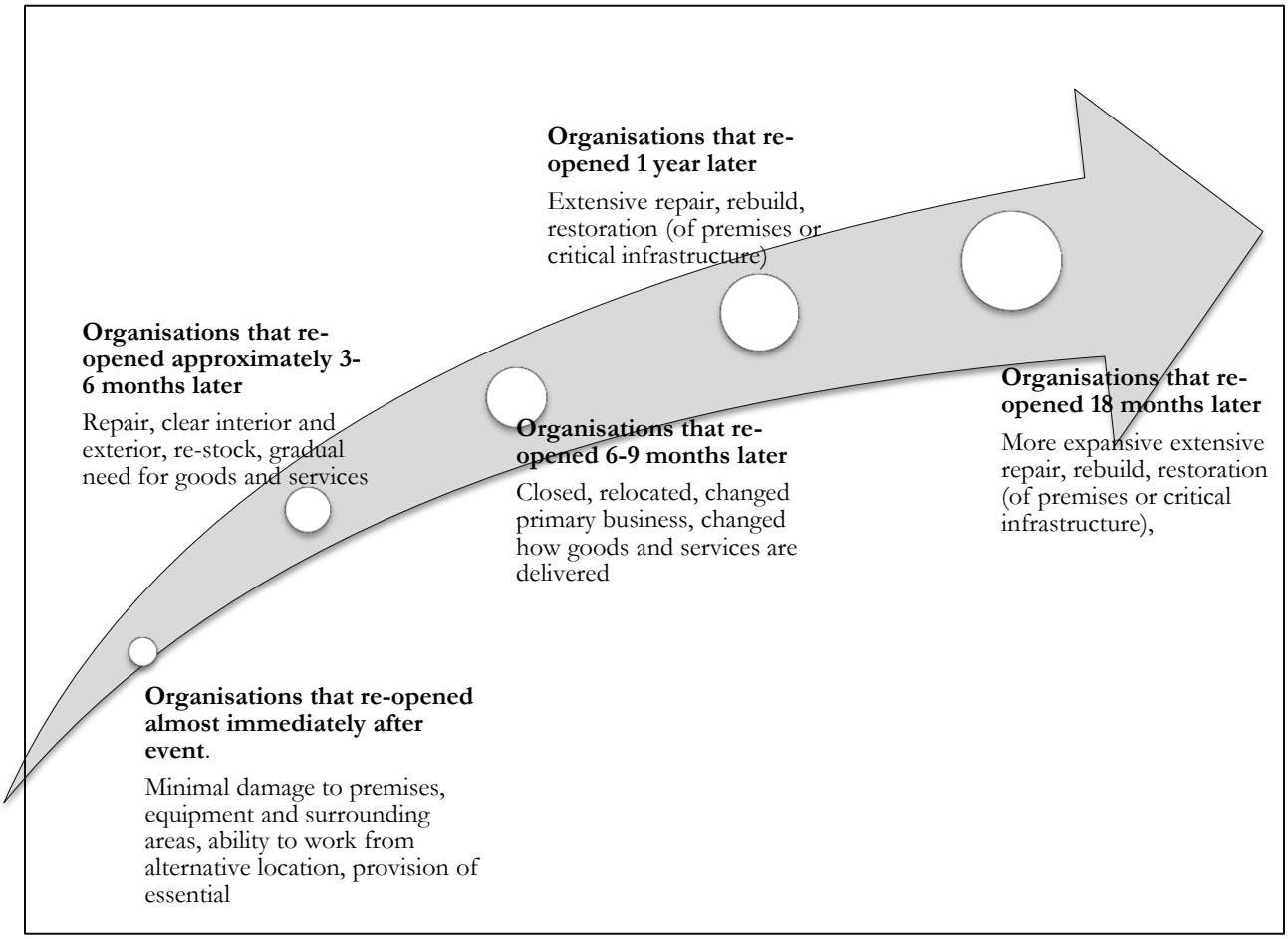


Figure 7-23: Organisational re-opening and short-term recovery trajectory after the 2010 and 2011 Canterbury earthquakes, for different organisations depending on when they resumed operations

7.7.2 An important note for crisis managers, emergency managers and recovery leaders

From the results in this chapter, it is apparent that the chaos of the response and short-term recovery phases after disaster may show recovery results that are counterintuitive when taken in the context of long-term recovery. Organisational recovery results in the short-term are not necessarily an indication of the final organisational recovery trajectory. For instance, building suppliers showing revenue losses when their products should be in high demand after the physical damage caused by an earthquake.

However, the results in this chapter are useful for other organisations that may find themselves in a similar situation regardless of the cause of the crisis or disaster. It is essential that organisations recognise that there are different parts to the overall recovery process; parts which call for different skills and types of resources. Additionally, it may be possible to use short-term recovery results and trends as one of the inputs in an overall recovery strategy.

Specifically for organisations, and pertaining to disasters of a regional nature such as that in Canterbury, the short-term recovery period may be a time when resources from local authorities (if at all available) have not been made accessible to organisations. Organisations may need to make individual plans to keep going while awaiting official aid. It may be that challenges and trade-offs may have to be made in the response and short-term recovery phase so as not to compromise longer-term recovery efforts. The accessibility and availability of a large amount of resources for an extended period after disaster are discussed further in chapters 9 and 10 of this thesis. Hills (2002) writes that the specific time and [physical] location of a disaster may disguise the fact that it may take a considerable amount of time to recover and that not all affected by the disaster will actually recover. For the organisations affected by the earthquakes in Canterbury, this means that not all of them will survive and not all will recover.

7.8 Chapter summary

From the above discussion, it can be seen that for the different industry sectors and for the organisations within those sectors, the different contributors to recovery affect the rate of recovery to differing degrees. From the extent to which the Canterbury region was affected by the sequence of earthquakes, it has emerged that organisational level characteristics only play a

certain part in the trajectory of organisational and sectoral recovery. For instance, organisation size measured by the number of full-time equivalent staff, the existence and practise of emergency plans and the organisation's average annual sales growth over five years were found to not significantly affect short-term recovery.

For all sectors, factors that did affect short-term recovery (positively and/or negatively depending on sector) include:

- → wellbeing of staff;
- → relationship with and capability of staff;
- → customer issues;
- → availability of different kinds of resources to enable production and delivery of goods and services;
- → organisational adaptation; and
- → combined planning between the stakeholders in recovery such as organisations, local authorities and the community.

Furthermore, organisations more affected by environmental factors such as service interruption to utilities as well as disruption caused by factors such as damage to equipment or machinery showed more post-earthquake revenue losses than organisations that were less disrupted. As well, organisations affected to a greater degree also operated fewer hours after the earthquakes. (see Chapter 9 for specific critical success factors (CSFs) for each sector's recovery)

For Canterbury, this chapter also showed that the components to short-term recovery (as defined in this thesis) do not account for all the elements that determine the recovery trajectory of an organisation or sector. Factors external to the organisation or sectors are involved, for instance the global financial crisis and to a lesser extent, the geographic location of the organisation. Environmental elements such as how the sectors interact with each other and with the wider economy, decisions on recovery (e.g. access to organisational premises) made by the Recovery Authority and insurance payments should also be factored in.

Furthermore, environmental factors that were not included in the list of contributors and components to recovery in some cases played a greater role in the recovery of organisations. Insurance, which most organisations had but which was subject to payment delays is one such component. For some organisations, this compromised their financial position. For organisations in and around the CBD, Recovery Authority ambiguity on access to the cordoned off area did not help recovery as they could not access organisational records and assets. Showing how these components can interact, the inability for some organisations to access the cordoned off area and retrieve documents further delayed insurance claims settlement. The global economic climate was a component that affected building suppliers. However, it is unclear to what extent this contributed to their revenue losses post-earthquake. For the Christchurch CBD and the town centres, geographic location is a contributor to their recovery. In the Canterbury earthquakes context, these locales were subject to proximity to the earthquake epicentre and also the existence of building stock prone to damage from earthquake shaking.

It should also be noted that due to the subjective nature of any disaster, the more significant contributors to organisational recovery will likely differ by sector and by disaster. This is evidenced by the different sectors having dissimilar signifiers of recovery. Additionally, the measure of recovery used in this chapter is post-disaster revenue changes in the short-term recovery phase. However, dependent on the purpose of the organisation, i.e. of the system, it would be prudent to use more than one measure of recovery in combination. These measures should be relevant to the organisations using them and can be defined by the organisations themselves.

In chapter 8, system dynamics techniques will be used for the analysis of how different elements, such as the contributors and signifiers of recovery within a system, interact to affect organisational recovery.

8 System dynamics of sectoral and organisational recovery

This chapter has the results of the use of system dynamics techniques in the analysis of organisational and sectoral recovery after the 2010 – 2011 earthquakes in Canterbury. As shown from the preceding chapter, recovery of an organisation in the aftermath of a disaster event should be considered within the context of a dynamic architecture that incorporates interdependencies and downstream effects. The industry and geographic sectors in Canterbury, in fact in any economy, are interrelated and affect each other's recovery. The reason for using the principles of system dynamics is to better understand system behaviour that influences the recovery of organisations and industry sectors as well as possible points of intervention in their recovery. Organisational or sectoral recovery is defined here as *when an organisation or sector can function and sustain itself (continually) in its new post-disaster environment.* From a systems perspective, three vital aspects should be kept in mind with this (or any) definition of organisational or sectoral recovery: (1) recovery is a process and takes time; and (2) the organisation, as a system and its environment, is dynamic and not static. Ultimately, the organisation's primary aim is of production and selling of goods and services. Accordingly, a third aspect (touched on in chapter 6.9 and discussed further in this chapter) is that the organisation or sector in continually functioning and sustaining itself after disaster, undertakes different activities in order to achieve this primary aim. For instance, in the response phase, the organisation while not producing and selling goods and services at pre-disaster capacity, engages in activities to return to this pre-disaster state; i.e. to recover.

In this chapter, with the use of system dynamics techniques, conceptual models of the system being investigated are developed to aid in the analysis and identification of the behaviour or system characteristics that influence organisational and sectoral recovery. A system is an *assemblage or combination of things or parts forming a complex or unitary whole* (R. A. Johnson et al., 1964, p. 367). A system is defined for and has a purpose and is encircled by its environment (D. H. Meadows & Wright, 2008). In this research the system is comprised of the organisations and sectors in the study, and the environment consists of any elements they interact with in recovery. The system dynamics approach can be used in any dynamic system with mutual interaction between elements, information feedback and circular causality (see chapter 2.2 for more detail). Each system dynamics model is built around a particular phenomenon: in this case the recovery

of sectors after the Canterbury earthquakes. The phenomenon being investigated defines the elements that are included in the model. This is helpful in representing the system and its environment. Importantly, system dynamics models are not predictive; they are used to explore the behaviour in complex systems with numerous interactions.

Every disaster contains some element of surprise and is unique. Therefore, the system dynamics models presented here are representative of the recovery of organisations and sectors as seen through the eyes of the organisations in this study. This means that factors not shown in the models are assumed to be constant or that their changes are negligible and do not affect the system's behaviour to a great degree. For the purposes of analysis in this thesis, it assumed that the factors not shown are held constant. This allows for the analysis to focus on the relationships between the elements of interest. In this case, those factors which have an influence on and influence the recovery of organisations and sectors. In effect, this is a use of the ceteris paribus clause used in science, engineering, economics and other disciplines. For instance, Schlicht and Thompson (1985) in their work on isolation and aggregation in economic modelling, write that *all factors not explicitly considered as variables are assumed to be fixed within an argument*.

Furthermore, also crucial to the analysis in this thesis and closely related to ceteris paribus, is that it is not the larger, complete, system under investigation. It is only a part of the wider system that is analysed; a part defined for the purposes of studying organisational and sectoral recovery. As such, it can be concluded that the analysis done here is only for a partial system. Another way to look at this is from Sterman's (2002) work in which he states that any system is the worldview, or mental model, of the individual who defined it. Having said this; despite the systems in this thesis being developed with information for the Canterbury earthquake organisational and sectoral recovery, there are some general lessons that could apply to many other organisations outside the region. The effects to organisations and sectors have not been ranked. This is because it is difficult to rank effects due to the multiple interactions within a system and also because the rankings would differ by sector. However, chapter 9 contains critical success factors (CSFs) for the recovery of organisations and sectors.

Dynamic systems share common characteristics such as positive and negative feedback loops, delayed feedback, oscillation and amplification. Positive feedback loops are reinforcing whereas negative feedback loops are self-correcting (or goal seeking). Feedback loops enable the transmission of information of the state of the system and influence the occurrence being observed. The various feedback loops in a system are dominant at different times and contribute to balancing the system. The presence of the feedback loops counterbalancing each other also leads to the emergent property of resilience. Apart from resilience, hierarchy and self-organisation are the other features of a system that enable the system to function well.

In a system, positive (reinforcing) feedback loops carry on until offset by a negative feedback loop or by the unavailability of one of the required resources to keep the positive loop going. This results in either *S-shaped growth* where the system reaches equilibrium, i.e. the system goal, or *overshoot and collapse* where the system exceeds its capacity to sustain growth and then reverses the direction of growth and attains equilibrium. In some cases, overshoot and collapse can lead to the destruction of a system. System dynamicists, e.g. Forrester (1969), Meadows (2008) and Sterman (2000), have written extensively on such system behaviour.

As stated earlier, the system and its environment affect each other. In this thesis, for the time horizon under scrutiny, the delays referred to are *environmental time delays*. These environmental time delays had an effect on the system (organisations or sectors as systems) and are shown in the system dynamics diagrams as orange (showing as light grey when printed in black and white) causal loop arrows.

Lastly, it is usually the case that there are multiple feedbacks loops interacting simultaneously in a system. This makes observation of interactions and effects more complicated. Therefore, in the systems analysis process, it is useful to start with a system in equilibrium to which a perturbation is introduced. This makes it easier to observe which elements are affected and in what way. In the case of the organisations and sectors in Canterbury, such a disturbance is the earthquakes. As well, the dynamic modelling allows for adjusting of various system parameters and noting their effects.

Systems diagrams

In this work, causal loop diagrams (CLDs), and to a limited extent stock and flow diagrams, are used to understand the behaviour of the system (see chapter 3 for more detail). In the causal loop diagrams, negative feedback loops are shown as a B (balancing) and positive feedback loops are shown as an R (reinforcing). CLDs have arrows from one element to another; the direction of each arrow shows the direction of effect. The polarity of each arrow denotes the relationship between the connected elements. Positive polarity shows that the elements change in the same direction while negative polarity indicates change of the elements in opposite directions.

CLDs are used for qualitative analysis and are used as a foundation for the stock and flow diagrams in this chapter. Stock and flow diagrams can be quantified and used for simulation. In this work, stocks and flows were included in the analysis for organisational recovery only. The quantification is done using information from interviewees as well as from other sources such as Statistics New Zealand. However, inspection of the resulting graphs suggests that the time horizon for this research covers the effects in the response and short-term recovery phases after the earthquakes: phases marked by great uncertainty. The full effects need to be observed at longer times, e.g. 4 to 10 years, after the earthquakes. Also, more information is required, from other sources, to be added to the quantified stock and flow diagrams if a more detailed analysis, leading to policy formulation, is to be done. This extra information is beyond the scope of this research to fully explore. The quantification and additional analysis of the stock and flow diagram for organisational recovery are included in appendix J.

Figure 8-1 is a simplified system dynamics causal loop diagram showing the negative feedback loop for organisational or sectoral recovery. It shows that *actual organisational or sectoral output* can be disrupted by external events, in this instance seismic activity. This results in a difference between the *intended organisational or sectoral throughput* and the *actual organisational or sectoral throughput*. A decrease in *actual organisational or sectoral output* leads to an increase in the *deficit in organisational or sectoral output*, hence the arrow having negative polarity. The information from the goal of the system, *intended organisational or sectoral output,* coupled with the state of the system, *actual organisational or sectoral output*, leads to knowledge of the gap, *deficit in organisational or sectoral output*. This then leads to the development of *organisational or sectoral recovery programmes* aimed at

closing the gap between the organisation's or sector's intended and actual throughputs. The direction of the negative feedback loop B denotes the direction of net effect. The feedback loop is negative because it acts to reduce changes to the system to achieve a specific goal. Hence, in Figure 8-1, the power and efficacy of *organisational or sectoral recovery measures and programmes* governs the organisation's or sector's rate of recovery. *Intended organisational or sectoral output* is considered an auxiliary variable.

The CLDs in this study are built primarily using information from survey and interview data from key participants in the system. Other input data are from government agencies and documents from various specialised areas (e.g. geology, engineering and economics). The combination of information from these sources, to generate the CLDs, led to the emergence of significant information that would have been difficult to visualise and comprehend had the system elements been observed individually. When elements in a system are considered individually, there is a possibility of concluding that some elements are more important than others and also not detecting the interactions between numerous elements. Sterman (1994, p. 305), showing the value in using system dynamics, writes that in dealing with complexity *people generally adopt an event-based, open-loop view of causality, ignore feedback processes, fail to appreciate time delays between action and response and in the reporting of information, do not understand stocks and flows, and are insensitive to nonlinearities that may alter the strengths of different feedback loops as a system evolves*.

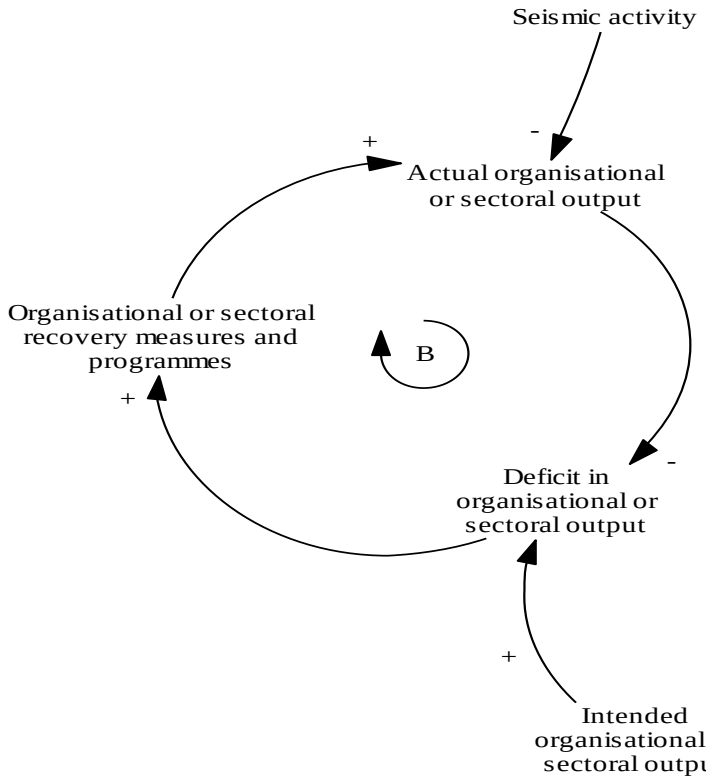


Figure 8-1: Simplified causal loop diagram (CLD) for sectoral and organisational recovery after the Canterbury earthquakes

Chapter arrangement

This section of the thesis is arranged as follows. The findings are presented first at the sectoral level and then at the organisational level. For both the sectoral and organisational levels, the models are divided into two main parts with respect to the earthquakes and to show the changing behaviour of the system over time. The first part covers the *response phase* and the second part is the *short-term recovery phase*. The response phase is mainly characterised by organisational and sectoral activity to prevent further damage after the earthquakes. There is also a lot of uncertainty in the response phase. The short-term recovery phase is when organisations and sectors work to return their situation to *normal* or to the desired recovery goal they have identified. It is shown in the analysis that the activities in these two time periods after disaster are considerably different and require different sets of skills and resources. At the sectoral level, only causal loop diagrams are utilised. In addition, at the organisational level is a stock and flow diagram depicting organisational recovery. The organisational level stock and flow diagrams are

presented in two parts. Part one represents organisational response and part two is organisational short-term recovery.

Both types of systems diagrams are accompanied by a description of the interactions between the agents in the system. Following on from this description of systemic exchanges is an explanation of the system characteristics that influence recovery. For clarity of presentation, the sectoral causal loop diagrams for each time period after the earthquakes are presented in three parts. The first part is an overview of the inter-sectoral effects involving all the sectors in this study. This is to illustrate the overall sectoral interactions. The second and third parts each depict only some of the sectors as well as environmental factors that influence their recovery. This is so that the interactions between the sectors and the environment are magnified for more detailed analysis. For instance, Sterman (2000) advises against showing all the important loops in a single complicated diagram as the information to be conveyed may be lost. Lastly, some of the diagrams have orange coloured causal arrows. This indicates a time delay in the environment that had a pronounced effect on organisations and sectors.

8.1 Sectoral response phase

Response is the period from the first moments after the shaking stopped to a few weeks after the earthquakes. For the 4 September 2010 earthquake, organisations reported that this phase lasted up to four to five weeks after the earthquake. This is except for organisations in Kaiapoi for whom this period was slightly longer. Organisations further reported that after the 22 February 2011 earthquake, the response phase lasted on average up to 10 weeks after the earthquake. As most organisations in this study were more affected by the 22 February 2011 earthquake (see chapters 5 and 6), most of the effects described in this section are from the period after this earthquake. The analysis again shows the dissimilar effects to sectors.

8.1.1 Overview of inter-sectoral effects in the response phase

The sectors interacted with each other in different ways. The causal loop diagram in Figure 8-2 demonstrates the propagation of earthquake effects between the sectors in the response phase. No environmental factors are shown in Figure 8-2. The clear boxes, e.g. *health of building suppliers sector,* represent the sectors in this study. The use of the word *health* is to illustrate the wellness of the sector at any point in time. The use of the word health, qualified by descriptive adjectives

like *well* or *ill*, also enables understanding of the state of a stock at a given point in time. The grey boxes on the causal arrows are the way(s) in which one sector affected another, with effects in the direction of the causal arrows. Using one of the links in Figure 8-2, *health of the critical infrastructure sector* and *health of Lyttelton Town Centre* as an example, the grey box *closure of or disruption to Tunnel, Port, roads* means that the change was in the sector at the tail of the arrow and the effects were to the sector at the head of the arrow. If the change in the health of the initiating sector is for ill, i.e. negative, and leads to ill health in the receiving sector also, the polarity of the arrow is positive. So, the change to the critical infrastructure sector was the damage and disruption of the Lyttelton Tunnel, Lyttelton Port and roads. Briefly, effects to Lyttelton Town Centre were that it was difficult to get in to or out of the town centre. As well, not shown in Figure 8-2 but in other causal loop diagrams are some of the multiplicative effects of difficulty in accessing Lyttelton Town Centre, for example to the retailers needing supplies. The causal loop diagrams are a representation of the system and are used to illustrate the more detailed explanation contained in the text. In the same way, the effects in the grey boxes are also explained in detail in the text.

The boundary of a system is defined dependent on the scope of analysis and on the information obtained. It should be noted that the CLDs are constructed using information provided by organisations in this study, through interviews and surveys. For instance, in the wider system, there are other organisations, sectors and elements that interact with those in this study but that have not been included in the CLDs. The details in the CLDs are those which organisations and sectors explicitly reported as affecting them and which they affected. Consequently, effects from other organisations and sectors and even some from the earthquakes, e.g. ground deformation, that were not mentioned by organisations and sectors are considered part of the system's environment.

In general, there was diminished capacity in all sectors in the period after the earthquakes. The different levels of effect were to infrastructure, organisational assets and employees. The individual sectors were affected to differing degrees by each of these three aspects. For example, infrastructure damage was more pronounced for hospitality, Christchurch CBD, the town centres and critical infrastructure. Whereas, FMCG and also critical infrastructure were very affected by damage to organisational assets, e.g. stock for FMCG and service delivery

architecture for critical infrastructure. All sectors reported that staff wellbeing was of primary concern.

The importance of critical services such as electricity, water, gas and roads, provided by critical infrastructure whose health was diminished, to other industry sectors became apparent as all sectors were disrupted by interruption to critical services. There was a gradual resumption of productivity for the sectors depending to what extent they had been affected and the nature of goods and services they produced. In essence, some sectors (e.g. critical infrastructure and some trucking organisations) had to step up while others (e.g. hospitality) had to step down or scale back operations.

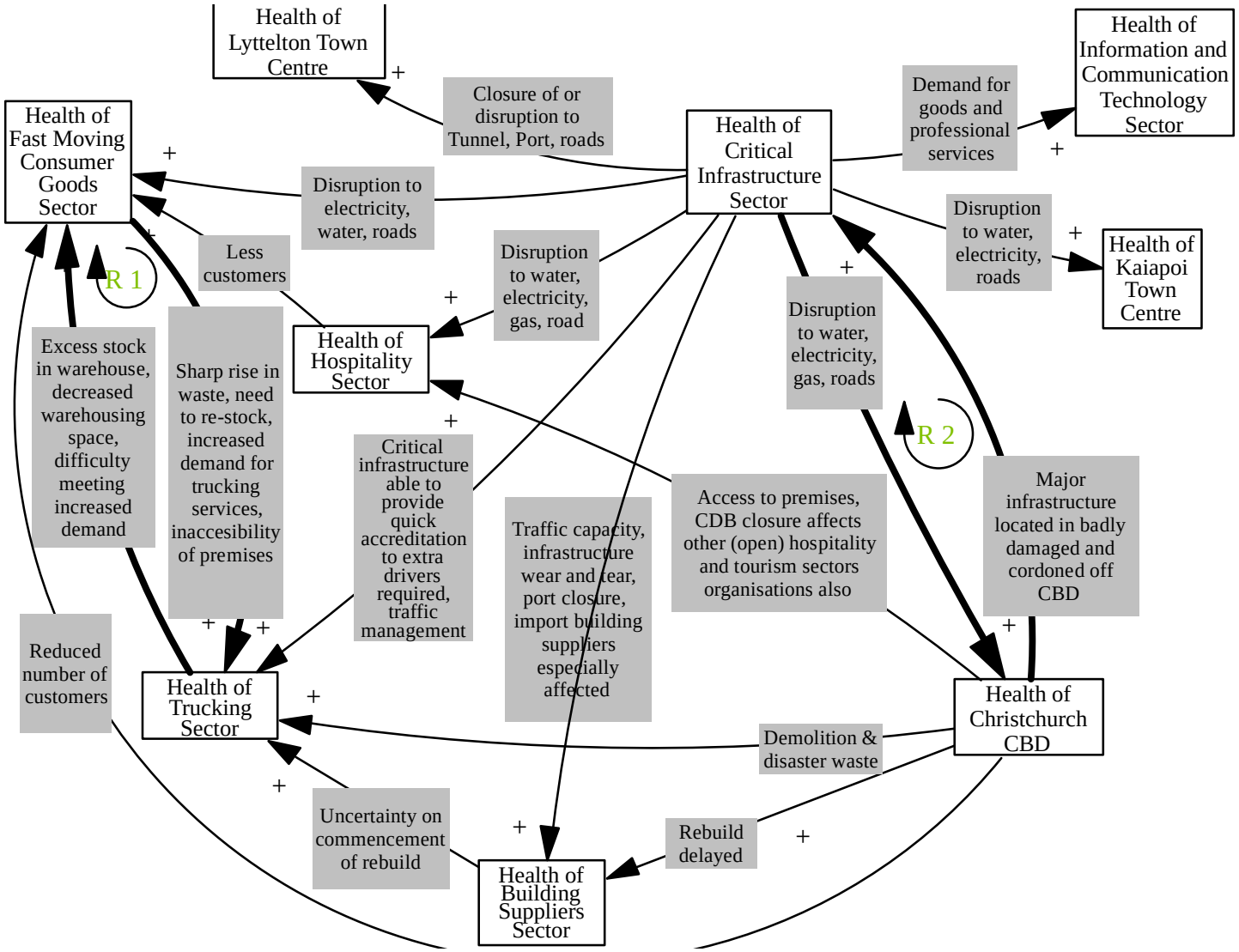


Figure 8-2: Overview of intersectoral effects in the response phase after the Canterbury earthquakes

In Figure 8-2 the critical infrastructure sector has interactions with all the other sectors in this study. This was a result of the interruption to critical services such as electricity, water, roads and to a lesser extent gas. The consequences of this varied by sector. For instance, one of the consequences to Lyttelton Town Centre was the closure of the Lyttelton Road Tunnel that connects it to the rest of greater Christchurch. The closure of the Tunnel affected the movement of people and goods into and out of the area. As well, the town was affected by the closure of Lyttelton Port, the main port for import and export in Canterbury. The building suppliers sector was also affected by closure of the Port and damage to other road infrastructure. Additionally, both the building suppliers and trucking sectors were affected by increased traffic on the roads due to reduced road capacity. The *health of building suppliers sector* also influenced the *health of trucking sector*. The uncertainty faced by building suppliers meant that they affected trucking organisations that worked with them.

The *health of the Christchurch CBD* has a bearing on the *health of the hospitality sector* as well as on the *health of the FMCG sector*. The hospitality sector organisations whose premises were in the CBD Red Zone had difficulty accessing their premises. In addition, damage to the CBD affected the tourism sector which also affected the hospitality sector. The deterioration of the CBD also meant that there was a relocation of a large group of people who were customers of the FMCG organisations that served the CBD. Some of the FMCG customers included hospitality organisations that were closed. Other more detailed consequences are contained in chapters 5 to 7.

In Figure 8-2 are the reinforcing feedback loops R1 and R2 for sectors in this study that showed especially high levels of interdependence: trucking-FMCG and critical infrastructure-Christchurch CBD. Reinforcing feedback loops, if left unchecked, continue in the direction of amplification unless slowed down or counterbalanced. Loop R1 involves *health of trucking sector* and *health of fast moving consumer goods sector*. Fast Moving Consumer Goods (FMCG) organisations had an increased need for trucking services due to excess stock waste that required disposal. The excess waste was caused by spoilage of putrescible products resulting from interruption to electricity and water supplies. Other stock waste was caused by breakage brought on by collapsed shelving and falling merchandise. This stock breakage and spoilage required a massive clean-up operation which took some time and resulted in closure of some FMCG organisations, e.g. supermarkets. As a result of the increased demand for trucking services from FMCG, one

would expect that the polarity of the trucking-FMCG causal arrow in Figure 8-2 should be negative. That is, that the increased demand for trucking services which could result in better health for the sector even as the health of the FMCG sector diminished.

However, this is not the case as closure of supermarkets resulted in trucking organisations not being able to deliver goods. Truckers reported that this affected them more as the supermarkets were closed for an extended period even after waste was taken away. This is because supermarket closure led to an accumulation of undelivered stock in trucking warehouses, which were at the same time facing the problem of reduced space because of earthquake damage (and potentially affected more of the trucking sector's customers, not just supermarkets). This also caused a backlog of unfulfilled orders for truckers that brought goods into the region. Loop R1 can be counteracted by clearer and timelier communication between the sectors involved, leading to the re-establishment of the supply-demand equilibrium. For instance, information from FMCG to trucking on how long closure would be. This information could then be passed on to manufacturers. As shown in chapter 5, reactions based on incorrect, incomplete or delayed information can be costly for organisations as they may vary orders or production schedules based on this information. This may cause excess or insufficient stock. The storage or production of excess stock also adds to costs.

Loop R2 is that of *health of critical infrastructure sector* and *health of Christchurch CBD*. It illustrates the consequences when infrastructure providers have major assets in built-up areas with a lot of unreinforced masonry buildings that were badly damaged by the earthquakes and subsequently condemned for demolition. A lot of the buildings in the Christchurch CBD were badly damaged, especially after the 22 February 2011 earthquake, which led to the cordoning off of the CBD. This resulted in limited access for critical infrastructure providers to parts of their networks in the cordoned off area and also to organisational records for those critical infrastructure providers with offices in the CBD. This inability to access the physical parts of the infrastructure affected the rate at which some repairs could be done. In the same loop (R2), organisations in the CBD area but not within the cordon were affected by interruption to critical services as they were serviced by parts of critical infrastructure networks within the cordon. These organisations on the periphery of the cordon were also subjected to slightly extended service interruption

times as they waited for critical infrastructure providers to gain access to the cordoned off area, make repairs and restore service.

For Figure 8-2, the sectoral response phase, both feedback loops are reinforcing. Reinforcing feedback loops carry on until there is a negative loop to counterbalance them or in the case of systems involving physical entities, until one of the required resources runs out. Following the response phase, it is seen that in the short-term recovery phase, these loops are no longer present. This is because, in both cases, after the initial information delay, equilibrium was restored as for R1 FMCG organisations could take delivery, trucking could deliver and for R2 critical infrastructure could access the CBD and make repairs even as it took longer for the repair and restoration of the CBD itself.

8.1.2 **Trucking, critical infrastructure, FMCG and Christchurch CBD**

Figures 8-3 and 8-4 show the more detailed interactions between *health of trucking sector*, *health of critical infrastructure sector*, *health of fast moving consumer goods sector* and *health of Christchurch CBD*. Figure 8-3 shows the overall interactions and Figure 8-4 better emphasises the loops. Orange coloured causal arrows are used to show time delays from the environment, which affected organisational recovery. Both figures contain the environmental elements that affect the recovery of the sectors shown and that are relevant to the interactions in the models. Some of these environmental elements include organisations such as local authorities: Christchurch City Council (CCC), Environment Canterbury (ECan) and other local councils (represented by hexagons). Elements such as finance also affect organisations. However, they have not been included here for two main reasons. First, in the response phase when organisations and sectors were trying to prevent further damage, finance was not the most important aspect. For example, in some cases, difficulty accessing personnel to assess buildings was more of a problem. Second is that the size of the regional economy was a buffer for some of the effects of the earthquake (see chapters 6.7.3 and 6.7.4). Also, in Figures 8-3 and 8-4 is text in black font that is not enclosed in boxes or hexagons. These elements are non-organisational or non-sectoral parts of the environment. i.e. they are auxiliary variables. They affect and are affected by the sectors in this study and, in the diagrams, have been left unenclosed for clarity.

Starting with Figure 8-3 the *health of the critical infrastructure sector* is affected by the availability of spare parts and by skilled labour. Both of these factors influence the rate at which repairs can be

carried out. *Health of the critical infrastructure* sector has an effect on the revenue levels of the Christchurch City Council (CCC). This then affects the *health of Christchurch CBD* as CCC is a major source of funding for the rebuild of the CBD. This is because CCC own buildings in the city centre, such as the Town Hall, that were damaged and require extensive repair or rebuilding. The *health of Christchurch CBD* affects *health of the trucking sector*. Some of the reasons for this include those trucking organisations that had customers in the CBD as well as trucking organisations that had an increased workload of debris removal after the earthquakes. Both the trucking and FMCG sectors are affected by excess *waste* (discussed in the previous section) and *excess stock in warehouses* which was caused in part by a *shortage of warehousing space*. The inadequacy in warehousing was brought about by *earthquake damaged warehousing*. Another link in Figure 8-3 is between Environment Canterbury (ECan - the regional council in the greater Christchurch region) and *health of the critical infrastructure sector*. ECan contracts public transport services from some of the critical infrastructure organisations. In addition, ECan decides when and which transport services and routes to run. After the earthquakes, services were greatly reduced, partly due to damaged infrastructure and also a reduced customer base, which affected the critical infrastructure sector.

In the response phase, *land use planning decisions* were important for FMCG, critical infrastructure and Christchurch CBD. The delay in availability of this information was caused in part by the delay in geotechnical assessment of land in the greater Christchurch region. As discussed in chapters 5 to 7, a delay in geotechnical inspections contributed to some of the delays in insurance claim settlements. Land use planning information, related to population resettlement patterns, was needed by FMCG and critical infrastructure providers for longer term planning of retail outlets and network structure respectively. Land use planning decisions were also needed for incorporation in repair, reconstruction and new build decisions. Knowledge of the proneness of land to liquefaction for instance, was valuable to organisations and insurance companies for decisions on proceeding with building repairs and new build and even had an effect on the revision of insurance policies.

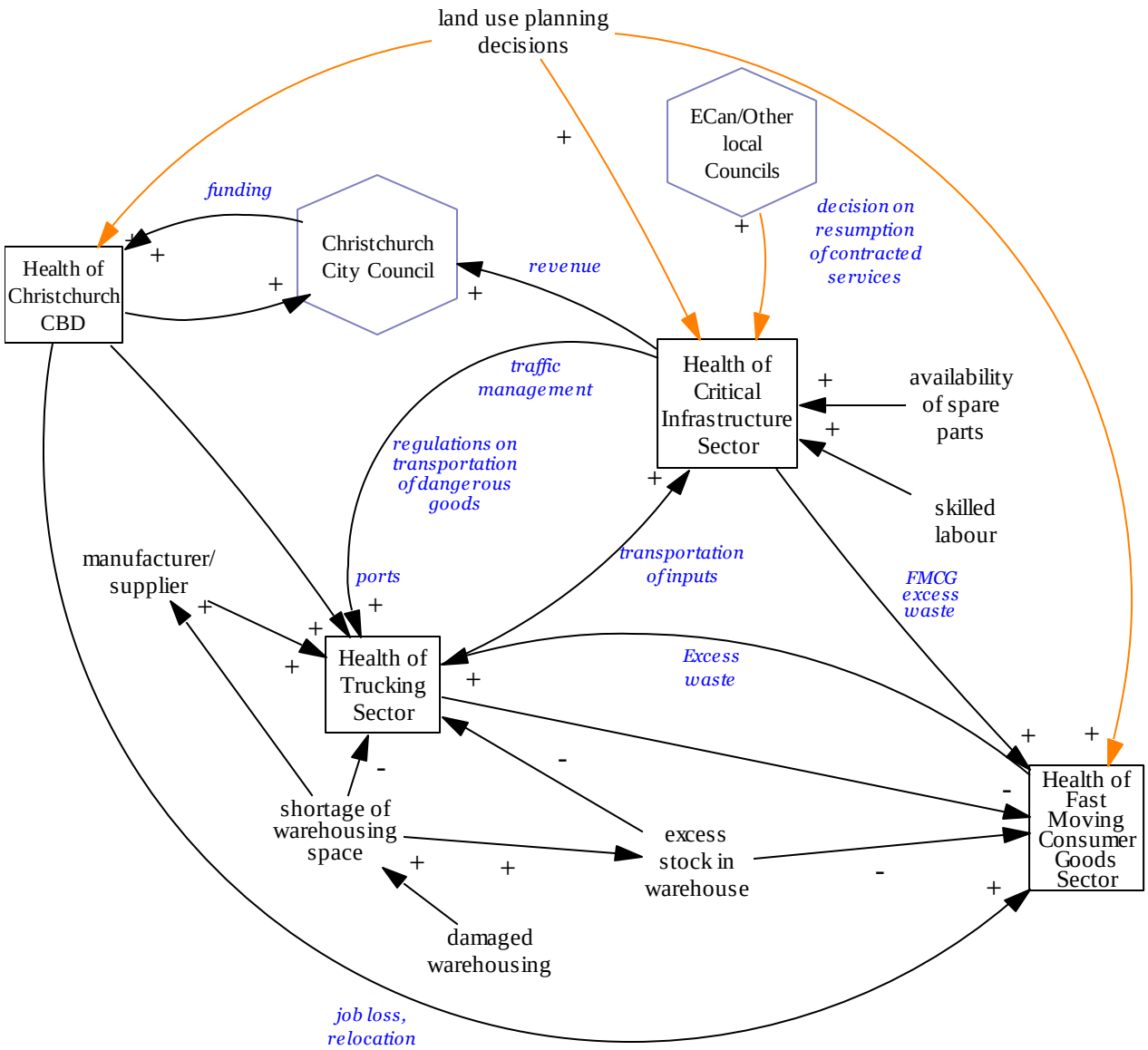


Figure 8-3: Causal loop diagram of the response phase for trucking, critical infrastructure, Christchurch CBD and fast moving consumer goods

Figure 8-4 is a version of Figure 8-3 with the feedback loops emphasised. There are five interacting feedback loops shown in Figure 8-4. As discussed previously, interactions of multiple feedback loops increases difficulty in observing system effects. This is because it is not easy to tell what the individual effects are. However, it is still possible to observe the emergent behaviour of the system. The five feedback loops in Figure 8-4 are:

→ loop R1 – *health of critical infrastructure sector, Christchurch City Council, health of Christchurch CBD, health of fast moving consumer goods sector, health of trucking sector;*
→ loop R2 - *health of critical infrastructure sector, health of fast moving consumer goods sector, health of trucking sector*;
→ loop R3 – *health of trucking sector, health of fast moving consumer goods sector*;
→ loop R4 – *health of trucking sector, health of critical infrastructure sector*; and
→ loop R5 – *Christchurch City Council, health of Christchurch CBD*.

In day-to-day affairs, some loops and resulting interactions may not be noticed or are taken for granted. This is to mean that they are vital but may be taken for granted. For instance, loop R5, *Christchurch City Council, and health of Christchurch CBD*. The Christchurch City Council is dependent on the Christchurch CBD for some of its revenue, in the form of rates and taxes. A damaged CBD means that some of these rates and taxes are reduced and in some cases cannot be collected. Unsurprisingly, critical infrastructure has the most connections of all the sectors in the figure showing the reliance of business on critical services. It can also be seen from Figure 8-4 that the sectors affect each other directly and indirectly.

Loop R1 includes critical infrastructure, Christchurch City Council (CCC), Christchurch CBD, FMCG and trucking. This loop shows how organisations are influenced by and can influence their environment. The loop contains links not only between the sectors under study but also other important sectors they relate to. The reduced revenue from critical infrastructure providers to CCC affects the type of construction projects that can be planned for and built in the Christchurch CBD. This could possibly also affect the recovery of the CBD in the medium-term. Also in loop R1 is the link between the CBD and FMCG. As a result of the earthquakes the number of people in the CBD reduced drastically. This caused a drop in customer numbers

for organisations outside the cordon and for those that serviced organisations that used to be in the Red Zone. FMCG organisations that serviced the CBD, both through hospitality organisations and through the loss of direct sales to the relocated organisations, reported being affected. This had knock-on effects for trucking organisations that worked with these FMCG organisations. Loop R2 has trucking, critical infrastructure and FMCG. The disruption of critical services resulted in excess waste for the FMCG sector. This meant that FMCG organisations had more than the usual demand for trucking services. The trucking sector was affected by the critical infrastructure sector by not being able to meet demand for transport of needed inputs.

Loop R3 is that of the FMCG and trucking sectors and was discussed in section 8.1.1. However, in Figure 8-4, some of the environmental interactions for this feedback loop are shown. The *shortage of warehousing space* affected *manufacturers* and *suppliers* who contracted trucking organisations to deliver goods to the FMCG sector. When the supermarkets were ready to re-stock, this had to be done gradually as not all their orders could be fulfilled immediately. For a short while there was a lack of some goods on supermarket shelves as the supply-demand balance was brought back to *normal*. The supermarkets however recognised that in this time period they needed to stock more of goods such as bottled water, chocolate and cigarettes as these were in higher demand after the earthquakes. This required constant readjusting of orders by all the members in this loop, which forms part of a supply web.

Loop R4 has the reinforcing feedback loop between the trucking and critical infrastructure sectors (the causal arrow from *health of trucking sector* to *health of critical infrastructure sector* is also part of loop R2). The trucking organisations also faced increased demand for delivery of ordered inputs from the critical infrastructure sector. The other causal arrow of loop R4 shows how the health of the trucking sector was affected by damage to roads, the Lyttelton Port, the Lyttelton Tunnel and bridges as well as by traffic management after the earthquakes. This led to truckers incurring increased costs in vehicle maintenance and longer delivery times. Loop R5 interacts with loop R1 and was discussed briefly in the analysis of loop R1. The Christchurch City Council funding shortfall affected the *health of the Christchurch CBD*. However, the rates and taxes from the CBD are some of the revenue sources for CCC. The manifestation of the loops in Figure 8-4 shows that aside from the preparation individual organisations engage in, they should also consider that external, environmental, factors would affect their post-disaster recovery and so must be included in planning. For instance, seismically reinforcing critical infrastructure while

still situating it in areas where buildings are vulnerable to earthquakes is only one part of the solution as the infrastructure itself may suffer moderate damage but be inaccessible for repair. Networks should also be designed with the environment they interact with in mind: first to minimise damage and second to enable quick restoration.

All the loops in Figure 8-4 are reinforcing. Again, it should be noted that this is the response phase after the earthquakes. In the case of organisational and sectoral recovery after the Canterbury earthquakes, except for loop R1, the positive feedback is counterbalanced in the short-term recovery phase. For loop R2, critical infrastructure services were gradually restored for use by FMCG and trucking; the excess waste was removed; and FMCG organisations re-opened and could take delivery of goods. Loop R3 is part of loop R2 and was also discussed in the overview section. Loop R4 shares links with loop R2.

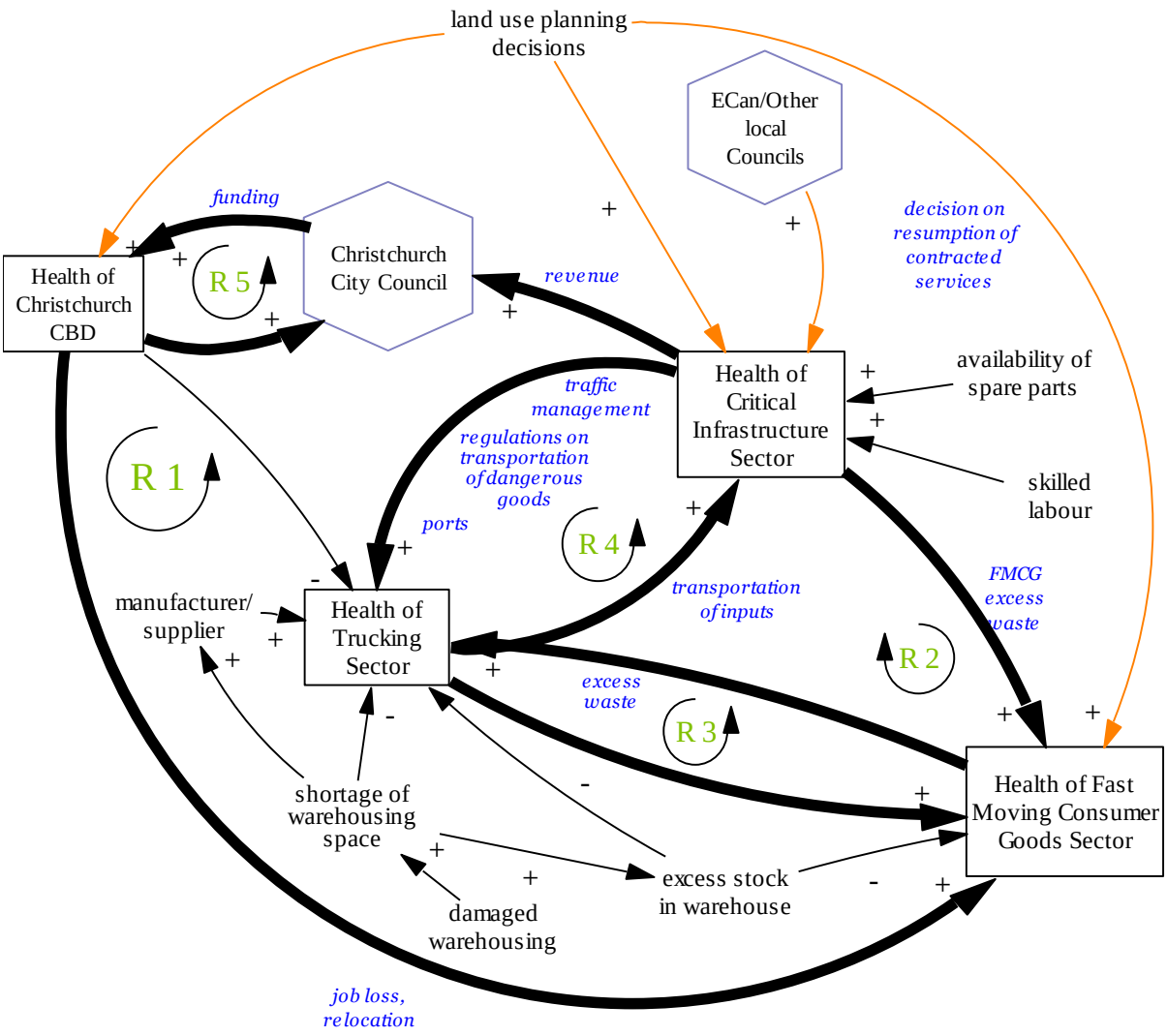


Figure 8-4: Causal loop diagram with feedback loops for the response phase for trucking, critical infrastructure, Christchurch CBD and fast moving consumer goods

8.1.3 Christchurch CBD, Kaiapoi Town Centre, Lyttelton Town Centre, hospitality, building suppliers and ICT

Figure 8-5 shows further sectoral and environmental linkages in the response phase. The mix of geographic locales and traditional sectors shows how the two affect each other's recovery. Similar to Figures 8-3 and 8-4, there are important elements in Figure 8-5 which are part of the environment for the focal sectors of this study. In addition to the Christchurch City Council, other sectors in the environment that interact with the focal sectors in this study include arts and crafts, agriculture and tourism. In Figure 8-5 are depicted numerous *environmental time delays* in the system's environment that were present in the response phase. These are denoted by orange

causal arrows. As pointed out earlier, the environment of the system is influenced by and influences the system; the environmental time delays shown are for elements that were important to organisations in that resources, e.g. information or manpower, were delayed. Environmental time delays are shortened to time delays. Also, some of the interactions shown have been discussed in sections 8.1.1 and 8.1.2 and are included here for completion of the model.

The *health of Christchurch CBD* affected the *health of ICT sector*. This is because ICT organisations had clients whose premises were located in the CBD Red Zone. Additionally, some of the ICT organisations were themselves located in the CBD prior to the 22 February 2011 earthquake. They sustained damage to equipment and disruption to operations. However, some ICT organisations were shielded from the prolonged effects of the earthquakes because of their *customer/revenue base outside Canterbury or New Zealand*.

In comparing the geographic locales, the Christchurch CBD has more interactions than either Kaiapoi Town Centre or Lyttelton Town Centre. Also, the *health of Christchurch CBD* affects the *health of Kaiapoi Town Centre* and *health of Lyttelton Town Centre*. The organisations in Kaiapoi Town Centre, like the ones from Lyttelton Town Centre, reported that the possible moratoria on commercial building and expansion could affect their long-term planning and viability. The moratoria were part of proposals from some organisations in and around the Christchurch CBD as a way of hastening recovery. The *health of Kaiapoi Town Centre* was also influenced by *land use planning decisions* after the extensive liquefaction caused by the 4 September 2010 earthquake.

In Figure 8-5, commercial and residential rebuild are shown separately because of different arrangements. The *residential rebuild* was managed by a specially appointed project management construction organisation. The *commercial rebuild* on the other hand did not have such arrangements. However, the pool of skilled labour and other resources required for both these parts of the rebuild had a great deal of overlap. Furthermore, some building supplier, CBD and town centre organisations in this study reported being affected more by *commercial rebuild* than by *residential rebuild*. For some organisations, this is because the delay in commercial rebuild and the difficulty finding suitable commercial accommodation affected their operations. The availability of *skilled labour* also led to time delays in *land use planning decisions* as there was a shortage of the

necessary geotechnical manpower to carry out inspections in a timely manner. There was also a shortage of skilled people to conduct *building inspections* and *building demolitions* as well as for the *commercial* and *residential rebuild*. The inspection time delays led in part to time delays in insurance claims being filed and settled. Time delayed insurance claims affected *cash flow* for some organisations. The *health of building suppliers sector,* while affecting the *commercial rebuild*, was itself affected by the *health of Christchurch CBD* and *residential rebuild*. Building suppliers were also affected by the *global financial crisis* which affected their customers in the *agricultural sector*. *Health of building suppliers* also affected *health of trucking sector*.

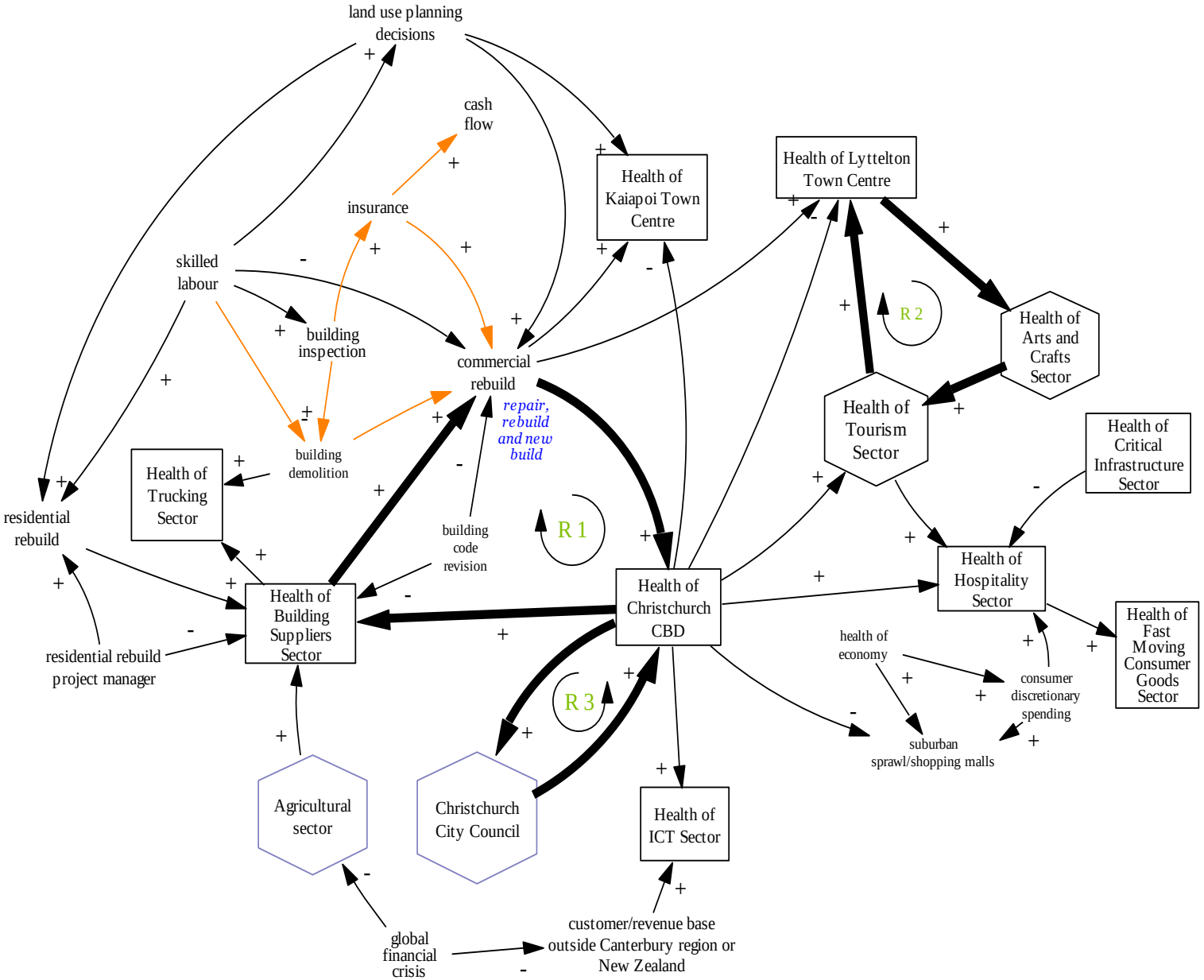


Figure 8-5: Causal loop diagram for the response phase for Christchurch CBD, Kaiapoi Town Centre, Lyttelton Town Centre, hospitality, building suppliers and information and communication technology

Loop R1 in Figure 8-5 is that of *health of Christchurch CBD*, *health of building suppliers sector* and *commercial rebuild*. The significant number of damaged buildings in the CBD meant that there was a substantial amount of building supplies required for rebuild and repair. However, the specifics of the repair and rebuild were not known and this affected stock forecasting for building suppliers. This then affected some parts of the *commercial rebuild* as building suppliers did not always have the right supplies at the right time. A time delay in *commercial rebuild* then led to time delays in repairing the parts of the CBD that could be repaired and influenced the *health of Christchurch CBD*.

Loop R2 of Figure 8-5 shows how the *health of Lyttelton Town Centre* interacts with *health of arts and crafts sector* and with *health of tourism sector*. The closure of the Christchurch CBD led to a drop in tourist numbers to the greater Christchurch region. This contributed to lower tourist numbers in Lyttelton also. Fewer tourists, in turn, affected not only hospitality but also the arts and crafts sector which Lyttelton claims to be the heart of. One solution to break this loop was the use of alternative ways of reaching arts and crafts customers, for example by using the Lyttelton Farmers' Market. Additionally, the promotion of more of the tourist attractions outside the Christchurch CBD could be used to draw in tourists.

Loop R3 was discussed in section 8.1.2.

8.2 Sectoral short-term recovery phase

From Figure 8-6, it can be seen that some of the effects from the response phase continued into the short-term recovery phase. Indeed, the effects of other interactions also manifested in this later phase. In the causal loop diagrams for the short-term recovery phase, the interactions shown are those that are the most significant for the focal sectors. This means that in some cases, some sectors are not affecting any other focal sector or are not affected by another focal sector.

8.2.1 Overview of inter-sectoral effects

Figure 8-6 is related to Figure 8-2 and represents the short-term recovery phase. In the short-term recovery phase different parts of infrastructure were gradually re-opened. Organisations

made tentative plans for how operations would proceed while they continually adjusted themselves to the post-disaster environment. The feedback loops from Figure 8-2 are no longer present in Figure 8-6.

As in the response phase, illustrated in Figure 8-2, in the short-term recovery phase the hospitality organisations within the Red Zone were still affected by the inability to access their premises while those outside the Red Zone were affected by decreased foot traffic. The *health of building suppliers sector* was influenced by damage to critical infrastructure as they sought to bring in building supplies. *Health of building suppliers sector* was also still influenced by *health of Christchurch CBD* as the major part the rebuild had not started. At the same time, the building suppliers were trying to keep up with demand for specific materials needed by the critical infrastructure sector. The state of the roads affected trucking organisations that were also affected by the delay in start of rebuilding and by the volume of waste generated from the Christchurch CBD.

The *health of ICT sector* was affected by an increase in demand for spare parts and for professional services required by the critical infrastructure sector. In the short-term recovery phase, both *health of Kaiapoi Town Centre* and *health of Lyttelton Town Centre* were affected by closure of some roads as well as repair of others. Organisations from the two town centres reported that the closure or repair of roads made it difficult to get around and for their customers to reach them. Road closure in Lyttelton affected *health of trucking sector*.

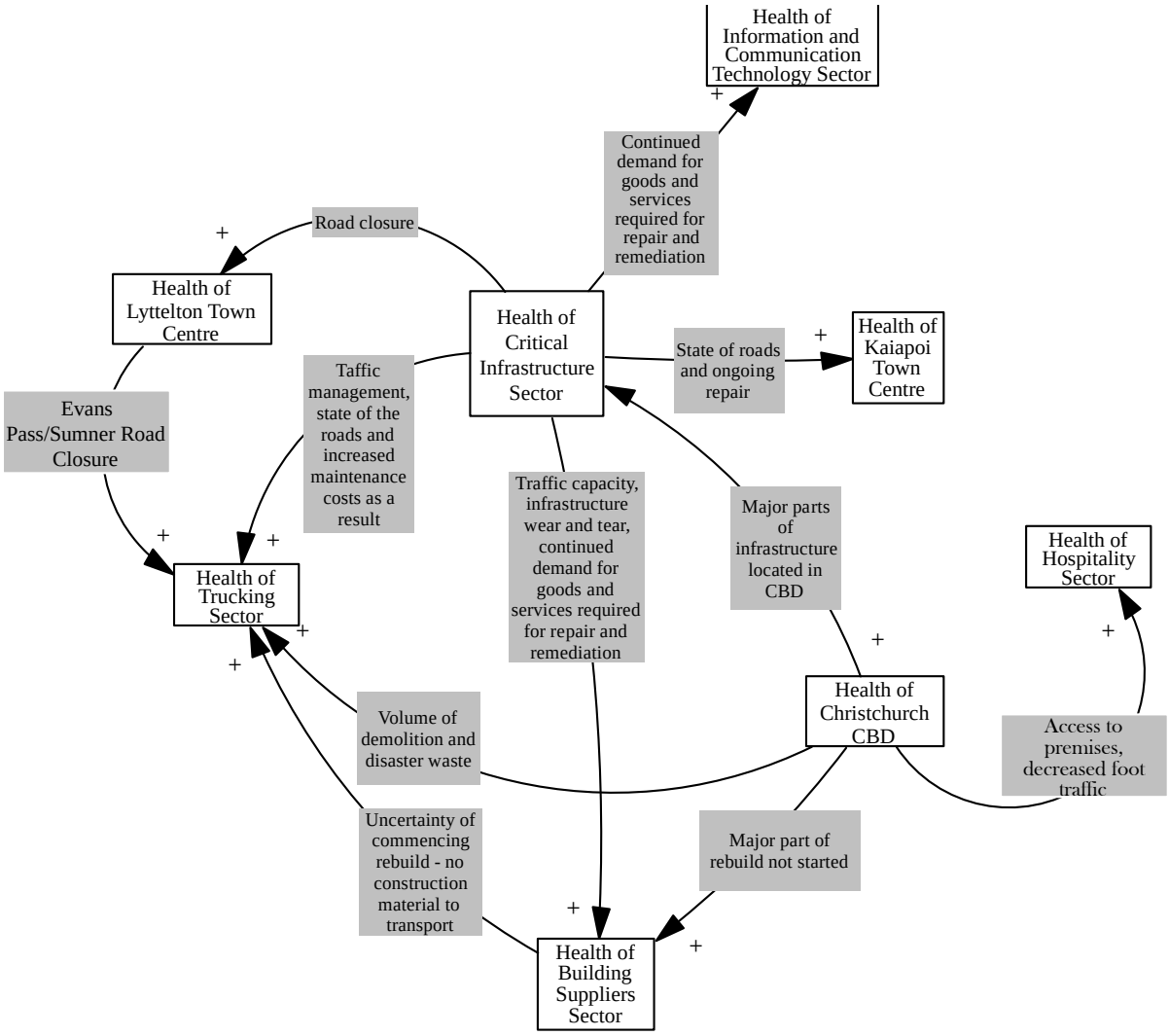


Figure 8-6: Overview of intersectoral effects in the short-term recovery phase after the Canterbury earthquakes

In the high level sectoral interactions in Figure 8-6, the FMCG sector is not present. This is because they reported that the major causes of disruption to their operations, as shown in Figure 8-2, were significantly reduced. Also of note, in looking at the interactions between the focal sectors only in the short-term recovery phase, there are no effects to the Christchurch CBD partly because it was cordoned off. Also trucking does not (adversely) affect any other sector although it is affected.

8.2.2 **Trucking, critical infrastructure, Christchurch CBD and FMCG**

Figure 8-7 is the short-term recovery phase associated with the response shown in Figures 8-3 and 8-4. These interactions involve *health of trucking sector*, *health of critical infrastructure sector*, *health of*

Christchurch CBD and *health of fast moving consumer goods sector*. Also shown are the continued interactions involving the regional (ECan) and local councils (CCC and others). In the short-term recovery phase, there is also the addition of the Central City Development Unit (CCDU). In 2012, the Canterbury Earthquake Recovery Authority (CERA) formed CCDU and appointed them to lead the recovery and rebuild of the Christchurch CBD.

In the short-term recovery phase, repair to damaged infrastructure and reconstruction of some of the needed infrastructure was underway. However, *land use planning decisions* continued to affect *health of critical infrastructure sector*, *health of fast moving consumer goods sector*, *health of Christchurch CBD* as well as ECan and other local councils. The continued environmental time delay on release of land use planning information was more pronounced in this phase. The delayed geotechnical assessments and information on which land use planning was based were an important part of the land-zoning issue that would inform what the future population profile of Christchurch would look like. This was mainly because of the effect to the long-term strategic plans of a lot of sectors such as the town centres, FMCG and critical infrastructure. Critical infrastructure organisations were faced with repair to massive parts of their infrastructure and also had to factor in repairs to infrastructure in areas that could be uninhabited in as little as nine months to two years. Not knowing which areas would be subsequently settled meant that network expansion planning was made more difficult.

ECan were also affected by land use planning decisions. This possibly had a bearing on the renewal of services contracted from the critical infrastructure sector. At the same time damage to infrastructure such as roads continued to affect the trucking sector who reported that they faced increased costs from more frequent maintenance and from more time spent on the road due to reduced road capacity and increased traffic.

Health of critical infrastructure was still affected by both availability of spare parts and skilled labour. Critical infrastructure organisations still reported not having enough skilled labour to carry out repair and remediation work[44]. They also stated that it was not always easy to acquire inputs needed for repairs. For the *Health of trucking sector*, the restricted use of critical infrastructure

[44] As at July 2012, there were reports in the media of an increase in advertised jobs for the greater Christchurch region. Also, Immigration New Zealand had created a special visa category for skills required in the earthquake recovery.

continued into the medium-term recovery period. This meant a continued adjustment to trucking schedules as well as incremental costs.

Loop R1 is that of *health of Christchurch CBD* and *Christchurch City Council* (CCC). In the short-term recovery phase, it became clearer how much monetary loss CCC would bear from loss of rates and taxes from the non-functioning CBD. This is in addition to reduced critical infrastructure revenue. This influenced funding from CCC towards the rebuild of the CBD which contributes to health of the Christchurch CBD. Loop R1 can be broken by the (gradual) re-opening and use of the Christchurch CBD.

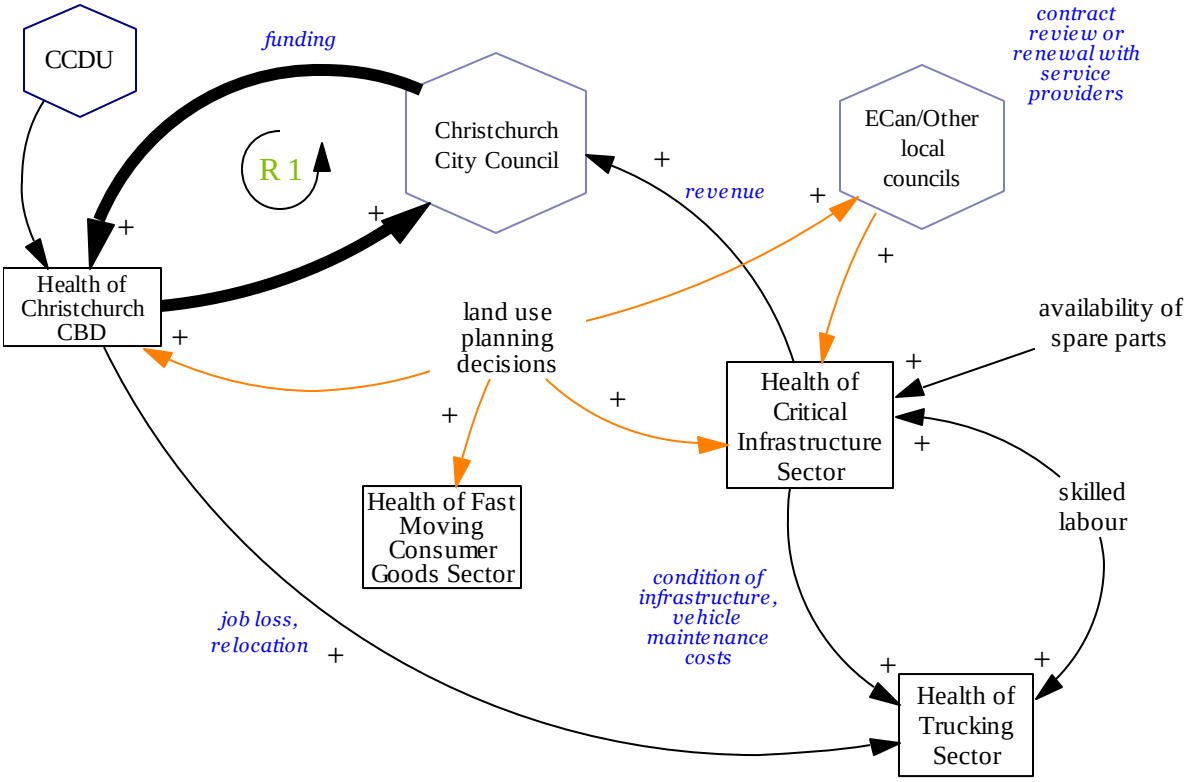


Figure 8-7: Causal loop diagram (CLD) of the short-term recovery phase for trucking, critical infrastructure, Christchurch CBD and fast moving consumer goods

8.2.3 Christchurch CBD, Kaiapoi Town Centre, Lyttelton Town Centre, hospitality, building suppliers and ICT

Figure 8-8 shows the short-term recovery phase system and environment of Figure 8-5. Two of the three loops from the response phase are still present. *Insurance* was still a problem in this phase. Apart from settlement of insurance policies, there was also a problem with the availability

and affordability of insurance. *Insurance* still affected cash flow for organisations. Furthermore, the effects of skilled labour to *building inspection*, *residential rebuild*, *land use planning decisions* and *commercial rebuild* were still being felt.

Land use planning decisions influenced *residential rebuild*. Post-earthquake, the land in greater Christchurch was assessed and categorised depending on soil vulnerability to earthquakes. This meant that *residential rebuild* and repair work was dependent on this information being available. This continued to affect *health of building suppliers sector*. Figure 8-8 also contains the interaction between *building code revision* and the *commercial rebuild* and repair. Some parts of the building code were revised post-earthquake. The code stipulated that buildings be built or retrofitted to greater seismic strength. This effect on *commercial rebuild* affected *health of Christchurch CBD*. Another link is between *building code revision* and *health of building suppliers sector*. Changing building codes might require the stocking of new building materials and the re-training of qualified tradespeople and others who work in the construction sector.

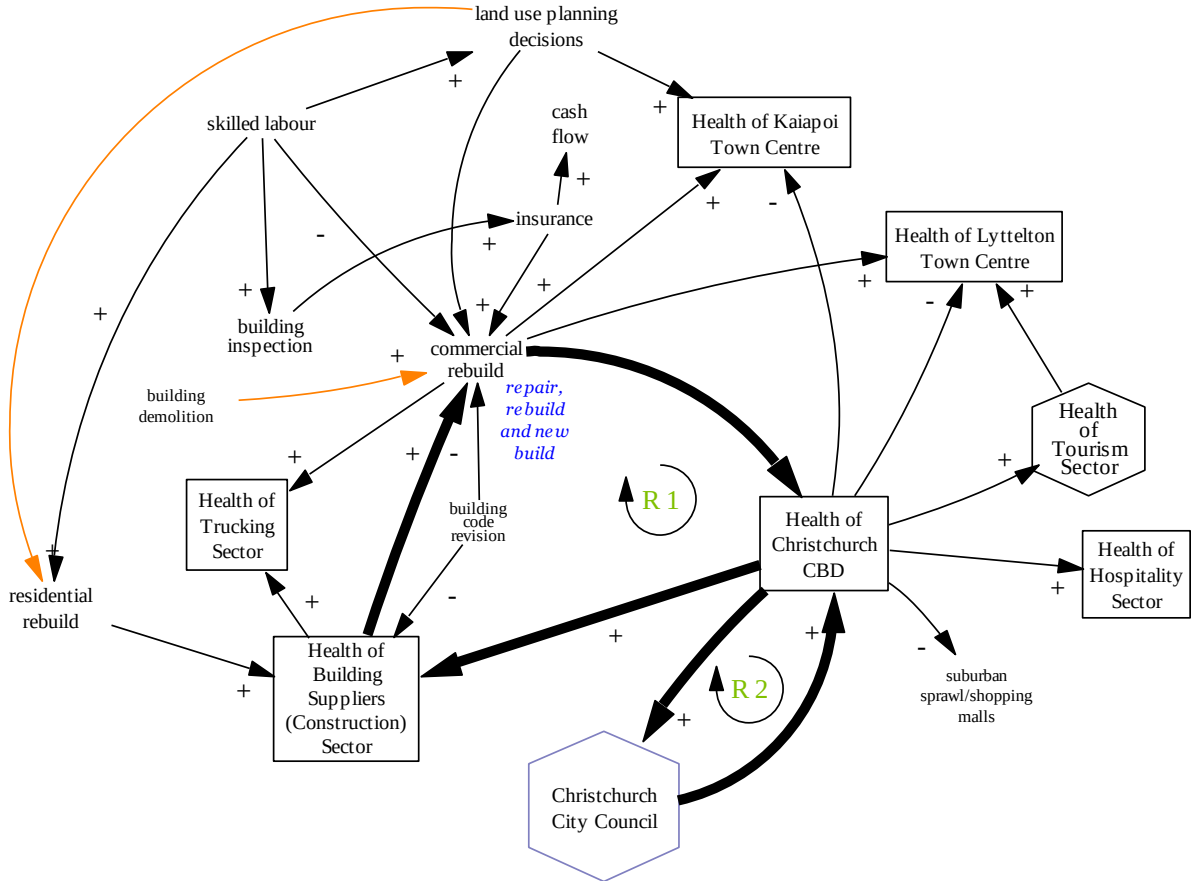


Figure 8-8: Causal loop diagram (CLD) for short-term recovery phase for Christchurch CBD, Kaiapoi Town Centre, Lyttelton Town Centre, hospitality, building suppliers and information and communication technology

For loop R1, *health of the Christchurch CBD*, *health of building suppliers sector* and *commercial rebuild* continue to affect each other. One cause of this is that the delay on development and release of the CBD recovery plan meant that even if a CBD land or building owner wanted to rebuild they could not. A major factor was that there was no master plan available for how the CBD would look. This meant that it was difficult to plan ahead for the type of building materials that would be required. This affected the *health of building suppliers sector*. Lastly, the lack of or small scale building activity meant that building supplier organisations still faced erratic demand. This erratic supply and demand led to difficulties in supplying material for other building projects. This delayed construction and repair of buildings meant that the *health of Christchurch CBD* was also affected.

Loop R2, *Christchurch City Council* and *health of Christchurch CBD*, and how it can be broken was discussed in section 8.2.2. Loop R1 can be broken by the availability of information for rebuild

of the CBD. Information on what would be rebuilt or repaired, when this would happen, what materials would be required and in what quantity. This would help building suppliers to forecast and positively affect the health of the sector.

Noticeably, Figure 8-8 still has positive (reinforcing) feedback loops R1 and R2. Both R1 and R2 have *health of Christchurch CBD* as a variable. In the short-term recovery phase, some of the issues surrounding repair and rebuild of the Christchurch CBD were still unresolved. This is further illustration of the time extended nature that recovery can take.

8.3 Modelling organisational recovery

Figure 8-9 shows the generalised stock and flow depicting the main interactions that affected response for individual organisations in Canterbury. Figure 8-9 also shows the main stocks and flows that were identified for organisational recovery in the response phase. Importantly, the value of this and other stock and flow models is in uncovering the patterns of behaviour of the system. This information can be used to identify important elements that affect recovery and in some cases points of intervention to effect recovery. As mentioned previously, for the purposes of this thesis, stocks will sometimes be referred to as levels. Levels contain information about the state or health of the system at any given time. In Figure 8-9, which has greater resolution at the organisational level, both reinforcing and balancing feedback loops are present.

Analysis of Figure 8-9 shows that the main levels in the recovery of organisations are related to their three main sources of vulnerability discussed in chapter 7: *health of the organisation* (organisational attributes), *available built environment* (infrastructure they use to deliver goods and services) and *health of the economy* (environmental factors). The *health of the organisation* is related to the volume of *customer or product orders* converted into the flow *throughput*. Contributing to *throughput* is *customer or product orders* and is the number of orders the organisation gets and can fulfill.

The other flow into *health of the organisation* is the *outshipment* of products. *Outshipment* is dependent on product sales and contributes to environmental factors such as *health of the economy* through the inflow *growth* of the economy. The level *health of the economy*, through its outflow *decline*, is also influenced by *uncertainty*. Contributing to the *uncertainty* that may influence economic *decline* as

people spend less, is the *recovery leadership calibre*. The *recovery leadership calibre* has a bearing on the *greater Christchurch recovery plan* which all sectoral and organisational recovery plans should ideally align with.

Available Built Environment influences the *disparity in available and needed accommodation*, has the inflow *construction, reconstruction and repair* and the outflow *building stock deconstruction*. The inflow *construction, reconstruction and repair* is influenced by the *disparity in available and needed* accommodation which is affected by the *needed rental or commercial accommodation*.

In the stock and flow in Figure 8-9, are both reinforcing (R) and balancing (B) feedback loops. Loop R1 shows the interactions between the *health of the organisation*, *availability of organisational reserves* and organisational *throughput*. However, *throughput* is partly reliant on *availability of organisational reserves* and on *available labour*. *Throughput* and *outshipment* of goods and services are inflows for the level *health of the organisation*. According to interviewed organisations, the pre- and post-earthquake measures of *health of the organisation* are usually in terms of sales, revenue and cash flow. Loop R1 shows that the better the *health of the organisation* the better the *availability of organisational resources* to contribute to *throughput*. Also the *availability of organisational reserves* is linked to the *crisis management ability* of the organisation and the two form loop R2. Part of the crisis management and subsequent recovery of an organisation is getting back to their pre-earthquake levels of *throughput* (production) or better which requires the prudent use of organisational reserves.

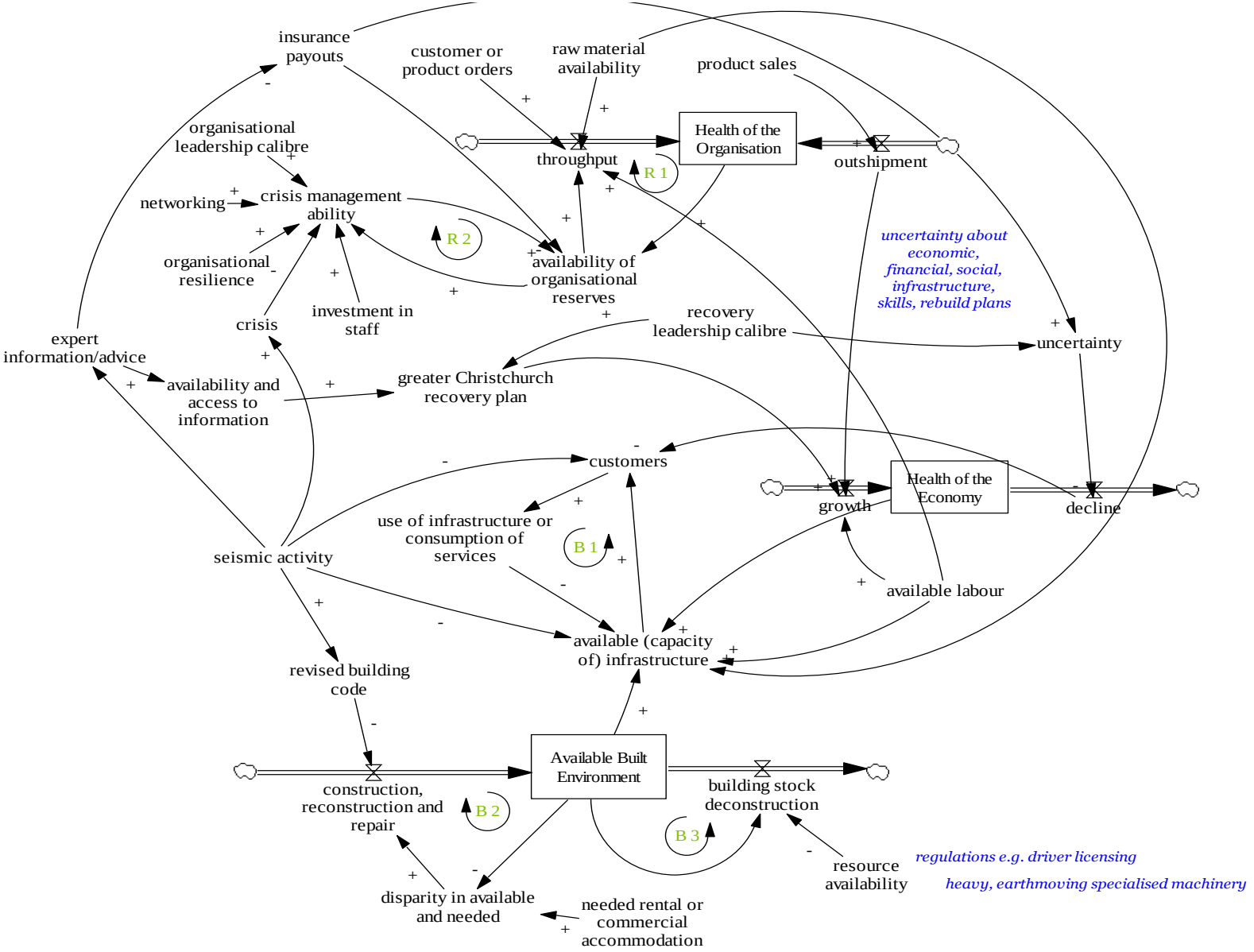


Figure 8-9: Stock and flow diagram of organisational recovery in the response phase after the Canterbury earthquakes

Loop B1 also involves resources, the *available (capacity of) infrastructure* after the earthquakes. *Customers* and *use of infrastructure or consumption of services* complete this loop. The *available (capacity of) infrastructure* is further affected by *seismic activity*. *Seismic activity* also influences the *customers* of loop B1. Loops B2 and B3 are both linked to the level *available built environment*. *Available built environment* influences *available (capacity of) infrastructure*. Loop B2 of Figure 8-9 shows the relationship between *available built environment* and its inflow *construction, reconstruction and repair*. The level of *available built environment* affects the *disparity in available and needed* accommodation which influences the inflow *construction, reconstruction and repair*. However, the rate of *construction, reconstruction and repair* is affected by the *revised building code*. Loop B3 shows the relationship of the *available built environment* and its outflow *building stock deconstruction*. In the response phase, this outflow is affected by *resource availability*.

Figure 8-10 shows the systemic interactions in the short-term recovery phase for organisational recovery. Seismic activity persisted into the short-term recovery phase and still affected customers, *available (capacity of) infrastructure* and *insurance*. It also affected *crisis management ability* through *crisis*. The delay in *insurance* carries on into this period and influences *availability of organisational reserves* as more are used up. *Insurance* also affects *uncertainty* which contributes to the *health of the economy* outflow *decline*. Continued *seismic activity* also affected *revised building code* which affected *construction, reconstruction and repair*.

Unsurprisingly, loops R1, R2 and B1 from the response phase still exist in this later phase. For loop R1, organisations that reported the strain on the *availability of organisational reserves* as they continued to deal with *crisis*. *Availabilty of organisational reserves* were used up through increased costs associated with repair, relocation or payment of overtime wages. Some organisations reported diverting resources meant for expansion to manage the crisis caused by the earthquakes.

In the short-term recovery phase, *crisis management ability* was still as important as in the response phase. Organisations reported that the type of leadership required in the short-term recovery phase is consultative as opposed to slightly autocratic in the earlier phase. Also, *investment in staff* made *crisis management ability* even more pronounced. Staff fatigue resulted from the ongoing earthquakes. This shows that management of staff and their personal situations is important.

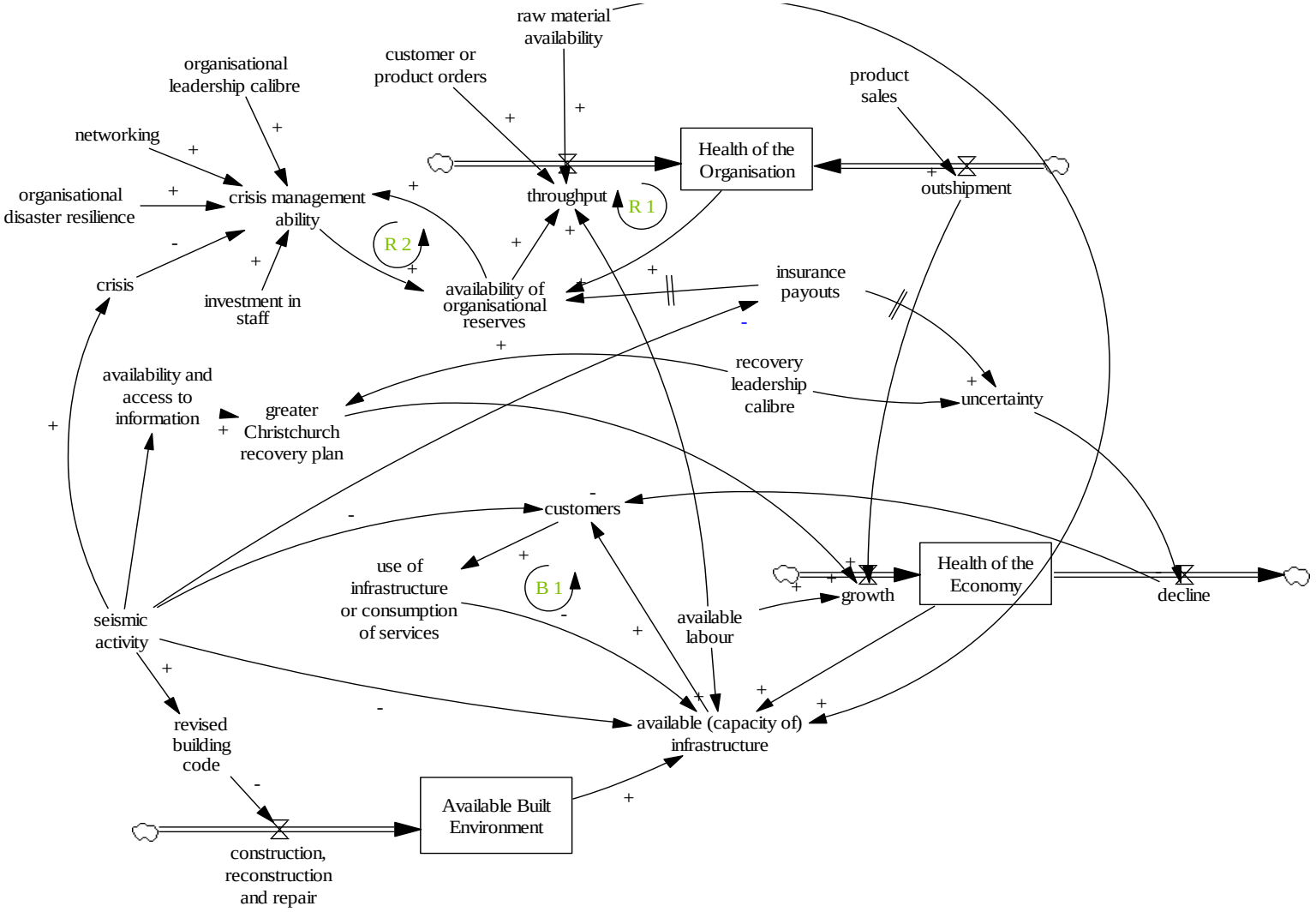


Figure 8-10: Stock and flow diagram of organisational recovery in the short-term recovery phase after the Canterbury earthquakes

Loop B1 persisted partly as a result of the ongoing *seismic activity* which sometimes made the repair or restoration of infrastructure difficult. This affects *available (capacity of) infrastructure*. One way of counterbalancing loop B1 is by acting to maintain the condition of assets in the face of ongoing seismic activity. In addition, the other influcnce on *available (capacity of) infrastructure,* the *use of infrastructure or consumption of services,* also needs to be worked on in parallel. However, critical infrastructure medium- to longer-term planning is still affected by *customers* as the decisions on land use had not been finalised 18 months after the earthquakes.

8.4 System behaviour influencing recovery

As described earlier, the structure of the system is very closely related to its behaviour. From descriptions of the system in sections 8.1 to 8.3, it is possible to abstract the system behaviour that influences the recovery of sectors and organisations. In the response phase after the earthquakes, there was a great deal of perturbation as organisations tried to understand how they had been affected and what the situation was. It was in this phase also that the initial assessment of buildings and infrastructure was done and repair work started. In the short-term recovery phase, many things were still uncertain; there were continuing delays and mismatches in needs and requirements. This was in addition to the ongoing earthquakes whose effects also had to be dealt with.

The system behaviours identified as affecting recovery after the Canterbury earthquakes and detailed below are:

- → interactions between system elements;
- → environmental time delays;
- → mismatches;
- → uncertainty;
- → hierarchy and self-organisation; and
- → resilience.

These specific system attributes are intertwined even if they are presented separately. They will also be discussed in chapter 9 in the context of aids, hindrances and points of intervention in recovery.

8.4.1 Interactions between system elements

Interactions between elements of a system and its environment are what lead to the emergence of complex behaviour. These interactions result in the bi-directional exchange of information and lead to different effects for different system actors. The interactions and their effects act to affect recovery.

8.4.2 Environmental time delays

Time is a crucial aspect of recovery and time delays can act to impede recovery. Time delays contribute to actors in the system reaching decisions based on incorrect information. In the figures in this chapter, the environmental time delays shown were the ones that significantly affected system actors and had cascading effects. System delays, on the other hand, occur in feedback loops and are the effect of a time lag in effects to one element from another. In the time horizon for this research, system delays were not yet apparent. The time delays after the Canterbury earthquakes were from various sources: building inspections, repairs, insurance payments, land inspections and overall recovery plans. In Table 8-1 is a list of the time delays in the system's environment after the Canterbury earthquakes. It should be noted that a contributor to the environmental time delays was the occurrence of the numerous (significant) aftershocks. With each aftershock the response clock was reset and transition to recovery required more effort. However, the continuing earthquakes presented a particular challenge: that of carrying on with the recovery efforts even as the aftershocks went on.

Table 8-1: Summary of major system delays affecting recovery after the 2010-2011 Canterbury earthquakes

Summary of major time delays, in the environment, affecting recovery after the 2010-2011 Canterbury earthquakes
Time delays in insurance payments
Time delays in organisations accessing their premises
Time delays in geotechnical or structural engineering assessments
Time delays in building demolition or deconstruction
Time delays in land use planning decisions
Time delays in availability of a plan for recovery and rebuild of the Christchurch CBD

From interviews with agents in the system, the speedier the recovery the better, as long as there is no compromise on quality. There were numerous time delays present in the system. There were delays in assessment of land and buildings which led to delays in the settlement of

insurance claims as the assessment information was required for insurance claims. Time delays in building assessments led to time delays in organisations accessing their premises and retrieving important organisational records or equipment.

However, some of the time delayed settlement of insurance claims happened even after assessment and reporting of building and land damage had been done. In some cases, this led to time delays in building demolition work. The longer it takes for a building to be demolished and the debris removed from a site, the longer it takes to start construction on that site or repair of nearby buildings. This affects other organisations in the system that might not be able to access their premises for instance. For some organisations, time delays in insurance settlements affected the organisation's cash flow or other resource reserves. Also, time delays in land use planning contributed to the difficulty some organisations had in making long-term strategic plans.

The time delay in insurance payments led to consequences including time delays in building demolition, inability to relocate for some organisations and the inability to effect repairs to damaged premises. Another related time delay was in insurance loss adjustors sending information back to affected organisations after assessment. This affected the organisations' knowledge of what the insurance company would pay out for after policy review.

Additionally, there were time delays in getting geotechnical and structural engineering experts to inspect land and buildings respectively. Part of the time delay was caused by there not being enough experts to carry out assessments in a timely manner as well as the delay in receipt of technical reports after the assessment was completed. This particular time delay was the equivalent of organisations competing for the same (scarce) resources to aid their recovery. As shown earlier, resource availability is vital for the recovery of an organisation after disaster. The engineering assessment of buildings and land is carried out for several reasons; having land and buildings inspected means that organisations know the extent of damage and what measures need to be taken such as repair or relocation. In Christchurch if the land or building was deemed irreparable, this was part of proof required by the insurance company. Another source of delay in reconstruction and repair was the non-availability of construction works insurance after the 22 February 2011 earthquake. This was mainly because of the ongoing aftershock sequence and insurance companies re-analysing and re-assessing risks. The system dynamics analysis in chapter

8 demonstrates that recovery is long and complex; time delays in the process also have the effect of draining the much needed hope and energy of those involved in recovery.

8.4.3 Mismatches

In investigating actions after the earthquakes, it can be seen that there was a disparity between when needs were articulated and when they were fulfilled. Mismatches contribute to the system being out of balance. A list of mismatches after the Canterbury earthquakes is contained in Table 8-2.

Table 8-2: Summary of system behaviour mismatches, for needs and requirements, after the Canterbury earthquakes

Summary of system behaviour mismatches after the Canterbury earthquakes
Mismatch in numbers of qualified personnel to conduct timely post-earthquake assessments and building demolition and number of buildings requiring assessment and/or demolition
Mismatch in available resources (e.g. machinery) to carry out building demolition and deconstruction and the number of buildings requiring demolition or deconstruction
Mismatch in available stock and needed stock post-earthquake
Mismatch in available finance and needed finance for post-earthquake recovery
Mismatch in available road capacity and the increased traffic on the roads after the earthquake
Mismatch in the need for timely, relevant information and the availability of this information

For instance, there was a need for qualified personnel to conduct assessments. However the scale of the job far outweighed the number of people on the ground. There was also a mismatch in when insurance money was required and when it was paid out, if at all. The rate of demolition was affected not only by decisions on who would pay for the demolition (insurers or building owners) but also on demolition machinery and manpower being available at the time it was required.

Another mismatch was in the response and early recovery phase and involved the FMCG and critical infrastructure sectors. The FMCG stock buffer did not match the demand for some goods needed immediately after the earthquakes. This is partly a result of a sectoral pre-earthquake use of just-in-time (JIT) storage and delivery of stock. JIT also led to the availability

of spare parts not matching the number of repairs to be carried out by the critical infrastructure sector.

Damage to and closure of the Lyttelton Port, the Lyttelton Road Tunnel and the Evans Pass/Sumner Road were a problem mainly for trucking and building supply organisations. At the time they had a great need for infrastructure, there was a restricted use of this infrastructure. Additionally, there was an increase in the number of trucking organisations after the earthquakes. This raised another discrepancy: that of the region's carrying capacity and the long-term viability of the sector. The idea of carrying capacity can also be applied to the number of skilled tradespeople required in the Canterbury area for the rebuild. If the rebuild were to take place at the same time in different parts of the greater Christchurch region, availability of labour would be just one of the problems. Another concern would be where to house the labourers who would come in from out of town (as was part of the plan by recovery authorities) and what the social implications of so many (mostly) men would be. All these are mismatches.

Other disparities were visible in the system. The recovery of Lyttelton Town Centre affected the recovery of the arts and crafts sector. Arts and crafts were affected by lower tourist numbers. However if tourists were to be encouraged to come to the greater Christchurch region, accommodation hospitality organisations would need to increase the number of guests they could host (the hospitality sector reported the loss of 70 – 80% of beds after the 22 February 2011 earthquake).

There were also mismatches in the need for and availability of information and communication. This is related to section 8.4.5. The uncertainty about what the CBD would look like or when it would be functional again caused affected organisations to make plans that involved not returning to the CBD in the medium-term. As well, information in the form of revised building codes should be in step with construction and training. Such a mismatch may lead to delays in starting construction work and could also lead to work not carried out competently due to newer requirements.

8.4.4 **Uncertainty**

There was a lot of uncertainty surrounding many aspects of recovery after the Canterbury earthquakes. In a disaster situation, it is expected that there will be uncertainty and that some of

this uncertainty is caused by the lack of information. However, it is imperative that ways of minimising post-disaster uncertainty should be determined. Uncertainty contributes to lack of system clarity and cohesion.

As with the delays, there were multiple causes of uncertainty. There was uncertainty about the overall recovery plan as well as how it would be financed and implemented. This was significant as it could affect organisational strategic decision making, most especially for organisations that were in the CBD. This plan was also important for any would be investors in the greater Christchurch economy.

Consequently, there was also uncertainty because of lack of information. Some actions to counter this uncertainty include articulation of the recovery plan, especially regarding finance and implementation. In the absence of concrete and detailed plans, information on where the planning process had got to and possibly how long it would take to craft the plan would have been beneficial to organisations and sectors.

Another factor that contributed to uncertainty was lack of detail in the original CBD recovery plan. Some *anchor* projects were planned for (e.g. the new Town Hall) but their precise locations in the CBD had not been decided. This had the effect that landowners did not know if their land would be part of an anchor project. Additionally, any other buildings to be erected in the CBD had to be placed in context of these anchor projects.

8.4.5 **Hierarchy and self-organisation**

The system exhibited self-organisation in reaction to the disruption brought about by the earthquakes. Self-organisation was possible because the system is made up of smaller units, in this case the organisation and then the industry sector. This is an example of the hierarchy of systems; the intermediate level connecting the greater economy to the organisation is the sector. For instance some ICT organisations acted to stabilise demand and supply difficulties by negotiating with customers modified delivery schedules as they worked to restart production and catch-up on lost productivity. The organisations said this worked due to having a good supplier-customer relationship established prior to the earthquakes. In other cases, competing organisations collaborated by sharing workspace and equipment.

From the actions taken by organisations and sectors to effect recovery after the earthquakes, it is clear that the system's tendency to self-organisation is a result of its capacity to learn, diversify and evolve. The complexity of the Canterbury system also made self-organisation possible. From the interview data, it seems that self-organisation was also brought about (made possible) because of the instability caused by the earthquakes. In the absence of the order organisations and sectors were accustomed to, there was a need to be creative and innovative in order to survive and recover. Carpenter et al (2001) emphasise that a resilient system need not be stable in the traditional sense of not changing and Perrings (1998) writes that system actors may actually desire system states that are not sustainable.

8.4.6 **Resilience**

In this thesis, the definition of recovery, which can be extended to the overall system, is *when an organisation or sector can function and sustain itself (continually) in its new post-disaster environment* while resilience is defined as *the ability to survive crisis and thrive in a world of uncertainty* (Seville et al., 2008). Resilience is an emergent property of the system, enables system survival and contributes to the achievement of system goals even when the system is faced with challenges. Also, it can be concluded that resilience and recovery are context dependent, as was shown with the differing definitions of recovery and resilience in chapter 2. Additionally, every system is defined for a purpose and is bounded by its environment (D. H. Meadows & Wright, 2008). The environment being the context within which the system operates. Furthermore, the resilience and recovery of a system should be managed to achieve the system's purpose. As such, in the context of the Canterbury earthquakes, the articulation of what recovery would look like was important (see sections 9.2.2 and 9.2.3) in shaping organisational and sectoral plans for recovery.

The changing dominance and existence of the feedbacks loops is a major contributor to the resilience of the system. From analysis of the model of the greater Christchurch system after the earthquakes, it can be seen that different feedback loops in the system were dominant at different times. For instance, some feedback loops that were in the response phase did not manifest in the short-term recovery phase.

Prior to the Canterbury earthquakes, the resilience of the system or parts of it may not have been immediately evident or even measurable. However, the perturbation resulting from the earthquakes, where the system's bounds were tested but not broken demonstrates that the

system is resilient. Table 8-2 contains interrelated aspects that contributed to organisational and sectoral resilience after the 2010-2011 Canterbury earthquakes. Some of these aspects include adaptation, diversity and self-organisation. Apart from the aspect changing dominance of feedback loops in Table 8-3, the rest of the aspects that contributed to overall system resilience are comparable to the characteristics of organisational resilience described by organisations in section 6.5.4. For instance, the ability of organisations to adapt to post-earthquake circumstances by working from alternative premises contributed to their resilience. The possibility for organisations to relocate in this way was partly attributable to the localisation of physical damage caused by the earthquakes as well as the quick restoration or non-interruption of utilities. This is also to do with system hierarchy. In thinking of Canterbury as one part of a larger system, Canterbury could still access resources from other parts of the system that are outside the region.

For some organisations and sectors, diversity of location, customer base and goods and services contributed to their resilience. However, for organisations with geographically spread customers, this was dependent on the organisations' ability to produce goods and services and to get these goods and services to their customers. For example, some organisations from the ICT sector that deliver their services online said they were still able to deliver goods and services to customers. An aspect of resilience that aided this was the organisations being able to communicate with their customers and inform them of the organisation's post-earthquake status. Information and communication being some of the ways in which uncertainty can be managed. Managing uncertainty, communicating with customers and restarting operations after the earthquakes all require leadership and self-organisation.

Table 8-3: Aspects contributing positively to system resilience after the 2010 - 2011 Canterbury earthquakes

Aspects contributing to system resilience after the 2010 - 2011 Canterbury earthquakes	
System aspects	**Details**
Localisation of earthquake damage	Differing degrees of damage to different parts of the greater Christchurch area
Changing dominance of feedback loops	Different loops dominant at different stages giving rise to changing system behaviour over time
Adaptation	Of people, relocation, adjusting mode of delivery of goods and services
Diversity	Of people, location, customers, goods and services
Bi-directional information flow between system agents	System agents give and receive information
Leadership and self-organisation	Leadership within sectors, and self-organisation in the form of partnerships
Hierarchy	For instance individual organisations making up sectors
Managing uncertainty (to certain extents)	For organisations, ensuring staff not made redundant
Recognition of complexity of recovery task and involvement of multiple stakeholders	Recovery agencies, organisations, community, local authorities
Recognition of limiting factors in recovery	Some limiting factors are finance, personnel, machinery

Conversely, there were aspects that when not managed properly led to a decline in resilience for organisations and sectors. One of these is the lack of relevant information and communication from recovery authorities as to when certain buildings could be accessed. Another aspect contributing negatively to organisational and sectoral resilience was the shortage of necessary skills that contributed to organisations being able to resume operations. Some of these include engineering skills for land and building assessment. As discussed in other parts of the thesis, such shortages had cascading effects.

The specific elements of organisational and sectoral disaster resilience are explored in detail in chapter 10. Again, the aspects listed in Table 8-3 emerged from the system that was examined. The systems view enables the identification of the different feedback loops in evidence, their role in recovery as well as in hazard mitigation and planning.

8.5 Chapter summary

This chapter illustrated, through the use of systems thinking, the interactions between system elements in the response and short-term recovery phases after the Canterbury earthquakes. In these two periods after the earthquakes, different feedback loops were dominant leading to differing system behaviour and effects. This emphasises that the structure of a system, the linkages between system actors, determines its behaviour. This chapter has shown that the system is influenced by and influences the environment and that system agents are affected

directly and indirectly by other agents. The examination of the linkages in the system led to the identification and explanation of specific system attributes that influenced organisational and sectoral recovery after the earthquakes in Canterbury. These are:

- → interactions between system elements;
- → (system) environmental time delays;
- → mismatches;
- → uncertainty;
- → hierarchy and self-organisation; and
- → resilience.

After listing the system attributes that contribute to recovery, chapter 9 follows on from this with information on specific elements that helped or hindered recovery after the earthquakes in Canterbury. As well, points of leverage that can be used to manage the system for recovery are pointed out.

9 Aids, hindrances and points of intervention in recovery

In this section, the information from chapters 4 to 8 is brought together and employed to determine the factors that aid or hinder recovery. In addition, possible points of intervention that can be used to influence system events are identified. All the aids, hindrances and points of intervention are shown in Figure 9-1 and described in the sections that follow (using the same headings). It should be noted that in a system, intervention can lead to *positive* or *negative* effects and *unintended* consequences. The aids and hindrances to recovery as well as the points of intervention are presented here individually for clarity, however, they are linked. Also, some of the aids, hindrances and points of intervention that have been discussed in previous chapters will not be discussed in detail; they are listed here for completeness.

As can be seen in Figure 9-1, some of the aids to recovery are actions that can be undertaken by organisations prior to or after a disaster event. As well, the points of intervention in recovery have been grouped into actions organisations can take; infrastructure relied on for organisational operations and environmental factors.

It should be noted that the aids, hindrances and points of intervention are not listed in rank order of importance. First, for different organisations and sectors, the rankings of these elements differ. What is important for individual organisations and sectors is the recognition of which of these elements affect them, to what extent, and how they can mitigate this. Second, ranking the importance of elements in a complex system is not easy because of the interactions between them that lead to this complexity.

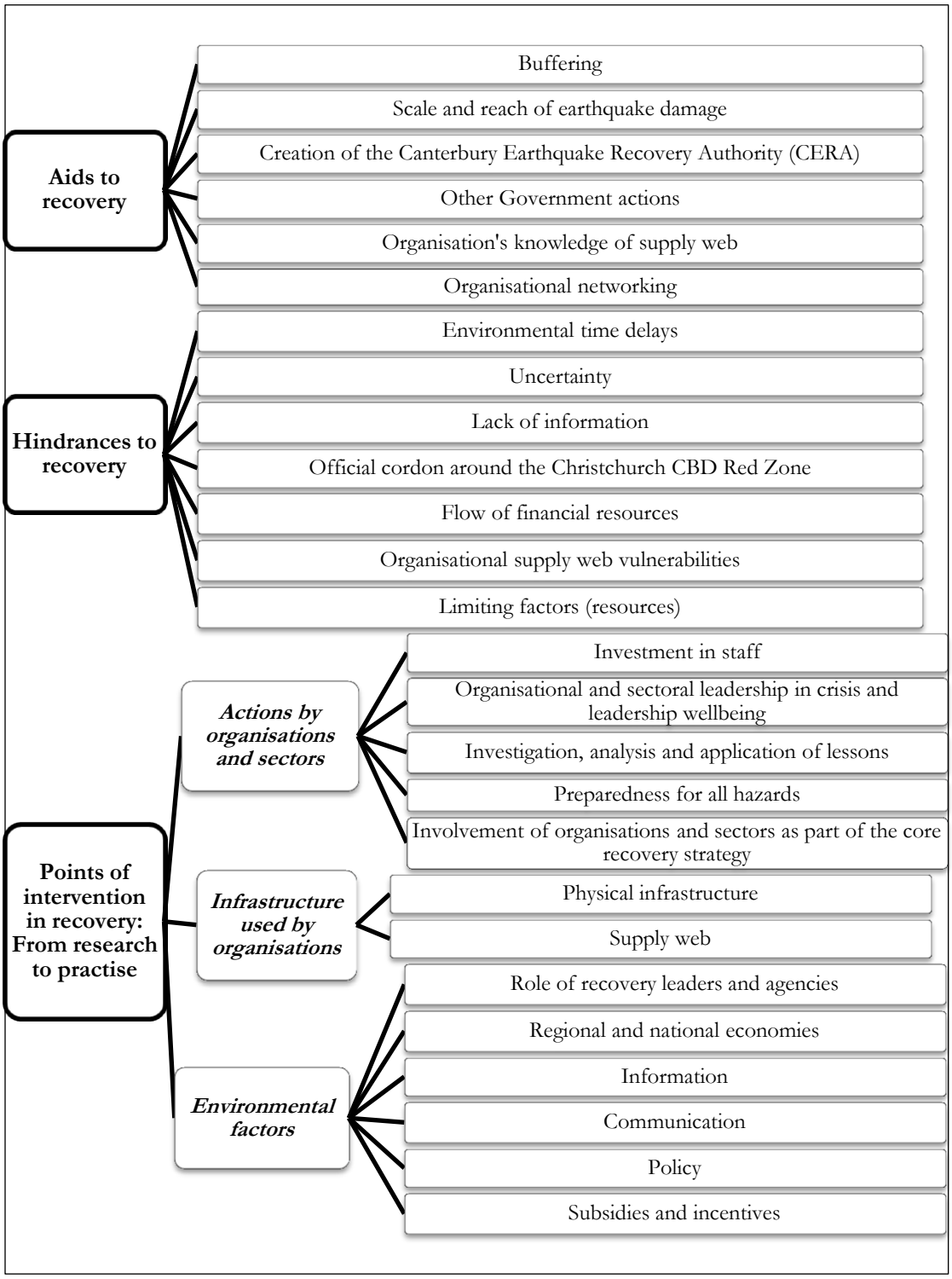


Figure 9-1: Aids, hindrances and point of intervention in recovery after the 2010-2011 Canterbury earthquakes

9.1 Aids to recovery

9.1.1 Buffering

Buffering here refers to actions or events that shielded organisations and sectors from some of the effects of the earthquakes, e.g. in giving them more time before they ran out of supplies. Some organisations and sectors had buffers that assisted in the short-term after the earthquakes. These buffers took different forms. For all of the sectors, the size of the economy of Christchurch also acted as a buffer as there was more than one main contributing sector to keep the Canterbury economy going. Additionally, the localised nature of the Canterbury earthquakes (discussed in section 9.1.2) made it possible to access available external resources.

The *good* average annual sales growth for trucking, FMCG and ICT (see chapter 5) helped, i.e. was a buffer, with cash flow which was necessary after the earthquake to pay for immediate repairs. FMCG also had small reserves of some stock (helpful in the short-term) both in warehouses and in the back of the store. These were helpful in meeting short-term demands when stores re-opened. Some FMCG organisations communicated that they used a just-in-time (JIT) system for stock delivery and stored little excess goods on their premises. Reasons for this include the cost of renting more floor space for excess goods and the convenience of having a distribution centre in Christchurch.

When asked, some critical infrastructure organisations reported having a store of spare parts in some of their warehouses. However, these spare parts were usually for sections of the network that in their experience broke down frequently. They did not have many, if any, spare parts for sections of the network that did not frequently breakdown but that sustained damage in the earthquakes and required replacement.

After the Canterbury earthquakes, organisations and sectors could plan for an increase in buffering capacity of major resources. An increased buffering capacity affords organisations time to re-start operations, where possible, while supply links are restored. The localisation of the damage in Canterbury meant that organisations could access resources to a certain extent. While having little excess stock on hand might be economical during business-as-usual, in the event of a regional disaster, holding more excess stock might prove to be an advantage for the recovery

of the organisation and the region. The downside of this is the increased storage costs mentioned and also possible stock damage should a disaster eventuate.

9.1.2 The scale and reach of the earthquake damage

The distribution of the effects of the earthquakes is related to the buffers mentioned in section 9.1.1. The adverse physical damage caused by the earthquakes, to structures, the ground and infrastructure, was confined to certain parts of the greater Christchurch area. This was a help to the recovery efforts. For instance, localisation of damage to the Christchurch CBD resulted in the loss of at least 65% of commercial building stock in the CBD. According to a Christchurch City Council (CCC) official interviewed, this represented approximately 7-10% of the city's overall commercial building stock (Christchurch City Council official, personal communication, 2012). This seemingly low percentage might be because of what was, pre-earthquake, unused commercial accommodation in Christchurch.

Damage to the Christchurch CBD resulted in the cordoning off of parts of the CBD for more than 18 months. This localised damage meant that some organisations could relocate to other parts of greater Christchurch that did not suffer the same level of damage. This is if the organisations had the means and the possibility to do so. This however raises the question of how much slack commercial accommodation there was in Christchurch before the earthquakes and what it was used for.

9.1.3 Creation of the Canterbury Earthquake Recovery Authority (CERA)

The Canterbury Earthquake Recovery Authority (CERA) was created by Central Government to lead and coordinate recovery efforts for the greater Christchurch area after the 2010-2011 earthquakes. See section 9.6.1. for more detail on CERA as an aid to recovery.

9.1.4 Other Government actions

Apart from the creation of a Recovery Authority, other Government actions such as the Earthquake Support Subsidy (ESS) and sending cash to Christchurch (electronic sales terminals were inoperable) were a help. See section 6.8.2 for details.

The ESS acted as a source of funds for organisations, in the short-term after the earthquakes. It afforded organisations much needed time to analyse how they had been affected by the earthquakes and what actions to take. Making cash available also enabled much needed trade to carry on and acted to keep the flow of money going in the economy.

9.1.5 **Organisation's knowledge of supply web**

The recovery of the supply web is an integral part of an organisation's or sector's recovery. The supply web enables the delivery of inputs and the shipment of finished product. From the supply web perspective, there are three main sources of disruption: from the supply side (suppliers), from the demand side (customers, discretionary, non-discretionary) and from within the organisation itself. The accounts of supply web disruption from organisations demonstrate that building redundancy into their supply web was one way that they could have overcome some of the effects of the earthquakes. For instance, one light manufacturer spoke of having more than one production line or main warehouse. However, such measures represented additional oftentimes unjustifiable expenses for organisations. It emerged that a flexible and agile supply web may have been a better option for instance through product substitution or through the acquisition of supplies from different vendors as main suppliers worked to come back on line.

An organisation's awareness of their position in the supply web, and its characteristics, affects not only their recovery but also affects organisations that rely on them in different ways. Inversely, the knowledge of the organisation's critical suppliers and what might affect them cannot be overemphasised. This awareness incorporates knowledge of which organisations on both sides of the web would be most inconvenienced if the focal organisation were disrupted as well as which of the focal organisation's supply web partners could most affect them in the case of a disruption. This knowledge can be used to prioritise customers so as to retain them especially in long-term recovery.

Some ICT and FMCG organisations spoke of getting in touch with their customers to verify what the effect of their being unable to deliver would be to these customers. They also worked out altered delivery schedules in collaboration. The organisations reported that this cooperation with their customers worked in part because of the trust they had built in the course of their relationships.

From interviews, no organisations reported having discussed supply web issues with their supply partners prior to the earthquakes.

9.1.6 Organisational networking

The organisation's network means the arrangement of connections, interactions or relationships that the organisation has with other actors in its system or environment. The interviewed organisations with more networks (formal and informal) seemed to be doing slightly better in their recovery efforts than the organisations with fewer networks. These networks were used for the exchange or pooling of resources and in the response and early recovery periods were vital for obtaining information. Organisations reported that the usefulness of the information was not the most important thing in those first few weeks especially after the 22 February 2011 earthquake. That they could get some information was helpful in itself.

Organisations referred to networking as a way of keeping up with information and trends inside and outside their industry that could aid their recovery. Networking was also used to find what upcoming work was available in their or connected industry sectors. Informal networks ensured that they were known to organisations that might require their services which could lead to more formalised arrangements or as a way to procure or get jobs by word of mouth.

9.2 Hindrances to recovery

There were multiple hindrances to recovery after the earthquakes in Canterbury. As with the aids to recovery, the hindrances are listed separately but are closely connected.

9.2.1 Delays

Time delays are a crucial aspect of recovery and can act to impede recovery. More details on the effects of time delays are presented in section 8.4.2.

9.2.2 Uncertainty

After a disaster situation, there will likely be some level of uncertainty. Uncertainty contributes to lack of system clarity and cohesion. Section 8.4.4 has more detail on the effects of uncertainty post-disaster.

9.2.3 **Lack of information (and communication)**

Information and communication are complementary. Communication can be thought of as the means of delivering or disseminating information. Consequently, good means of communication does not mean that the information is right or adequate for the intended purpose.

Information is a precious commodity in disaster recovery and the deficiency of it often leads to uncertainty, misinterpretation or incorrect assumptions as people look to fill the void. The lack or slow release of information post-earthquakes added to the uncertainty of the plans for recovery especially for the Christchurch CBD. This affected those organisations that wanted to return to or invest in the CBD for example. However, even as the lack of information was a serious issue, there needed to be a balance between speedy decision making and long-term planning. The period of recovery from disaster is a chance to engage in long-term disaster preparation and mitigation activities.

The dearth of information was also in the residential land zone planning. It was unknown for long periods of time which areas would be declared irreparable[45]. This of course had a bearing on the post-earthquake planning of organisations in the critical infrastructure, FMCG, Kaiapoi Town Centre and Lyttelton Town Centre organisations. Just because an organisation's assets are undamaged does not mean that their recovery will not be affected by other factors such as customers moving away from the area.

After disaster, both the means of communication and the content of the information communicated are vital. Organisations require information in order to make meaningful strategic plans for instance. Information should be available, relevant and timely. For example, in greater Christchurch, information on land zoning was delayed and unclear. This meant organisations did not have the right information on population profiles to use in business and recovery decisions. Also, the delivery of information, i.e. the means of communication, should suit the situation. In some cases it may be better to inform using physical mail while in other cases, social media may suffice.

[45] The details of the residential land zone offer can be found in chapter 5.

In a positive aspect of information and communication, the trucking and FMCG sectors worked together on supply and demand instability issues. This illustrates the criticality of communication and collaboration after disaster as well as in peacetime. One of the system effects in this case is the bullwhip effect (Sterman, 2000) caused by the different elements involved in this loop having incorrect or inadequate information about stock requirements in the supply web. This can cause the variability of orders to increase further upstream in the supply web.

9.2.4 **Official cordon around Christchurch CBD Red Zone**

The cordon around the Christchurch CDB Red Zone was put in place for several reasons such as the protection of the public from falling masonry after extensive damage to buildings caused by the 22 February 2011 earthquake. The cordon, while growing progressively smaller, was maintained while the demolition of buildings was done. In addition, the cordon was used as a physical control point by the authorities for anyone wanting to access the CBD Red Zone. Any individual wishing to enter the cordoned off area had to seek official permission and sign consent papers.

However this procedure did not stop people getting into the cordoned area illegally. This worried many business owners who were concerned as many of them faced difficulties in their trying to access the area legally to check on what damage their property had sustained, for insurance purposes as well as for the retrieval of equipment, information or stock. They expressed concern at the looting that took place as they had expected that the authorities would have provided adequate security to stop the wrong people gaining access to the Red Zone. This prompted some building and business owners to illegally enter the cordoned off area, admittedly at risk to their own lives, as they felt that their premises and belongings were unsafe. This was a case of separate decisions made by individuals aimed at achieving their own interests partly due to a lack of credible information and assurance from those officially tasked with leading the recovery of the greater Christchurch area (see chapter 6.9 on leadership and trust). The existence of the cordon was also a source of uncertainty.

9.2.5 **Flow of financial resources**

Money is one of the crucial attributes in recovery. It enables the carrying out of many other activities. One way to keep money (and capital) flowing is through the settlement of insurance claims. Insurance has been discussed in relation to delays and mismatches. Apart from the delay in insurance payments, organisations reported that the non-settlement and the non-availability of insurance policies affected them in a number of ways. Some organisations were affected because banks were not lending money to organisations with no insurance policies; this was especially so in cases of relocation when organisations could not get new insurance policies for new premises. Additionally, other organisations could not get contractors to repair premises because some contractors could not get contract works insurance.

The role the insurance industry played in the Canterbury earthquakes merits special mention as New Zealand has a high earthquake insurance penetration rate (J. Johnson, 2013). The delay in paying out insurance claims was a problem for a lot of organisations in Christchurch, especially the small- to medium-sized organisations. However, some contextual and case study interviewees stated that another aspect of insurance was the uncertainty of future insurability; both the availability and affordability of it.

One of the reasons Christchurch got into the insurance situation it was in was because of the management of expectations. As discussed earlier, the seismic risk for Christchurch was known, even if the faults that caused the Canterbury earthquakes were not. However, risk managers did not want to be seen to be pessimistic and may have downplayed the worst case scenario (CEO, personal correspondence, 2012). The focus was instead on Wellington and the Alpine Fault. Herein lie lessons for organisations in other parts of New Zealand that there are multiple hazards that should be considered. Additionally, perhaps there is a need to spread the risk in other ways and not just through traditional insurance. For Christchurch, and by extension New Zealand, this requires a rethink of how disaster risk is perceived. However, it should be noted again that the 22 February 2011 earthquake exceeded by a considerable margin the maximum credible earthquake assessment.

The Canterbury earthquakes also highlighted some major loopholes and further mismatches in existing business interruption insurance wording and policy. Some organisations did not get paid their business interruption insurance because their insurance company deemed that they *could*

open the door and trade. However, by law all buildings had to be checked and certified by qualified personnel before they could be used again. As previously mentioned, there was a shortage of people with the required skills to carry out these assessments which meant that there were organisations that were caught in limbo. The insurance issue was further complicated by the tiered insurance system for disaster. The Earthquake Commission's (EQC) declarations of certain earthquakes as *events* for households and contents were not matched to the definition of *events* that commercial insurers used.

9.2.6 **Organisational supply web vulnerabilities**

The supply web includes any resources the organisation needs to produce goods or deliver services. This can be employees, raw materials, customers, suppliers, utilities or technology and highlights anew the many ways in which organisations can be disturbed. A supply web can also have first and second order ripple effects beyond the affected organisation (Sheffi, 2007). First order effects are to the customers and suppliers of the organisation, while second order effects are to customers and suppliers of customers as well as customers and suppliers of suppliers (and any other entities that can be affected). From the interviews, two aspects are apparent for the supply web relationship between two (or more) organisations;

- → on how many levels and to what degree and extent the organisations are connected; and
- → the criticality to one organisation of the goods and services offered or bought by the other organisation.

From interviews with the FMCG sector, a third aspect is the number of organisations reliant on one supplier, for instance the number of retailers dealing with one supplier. This is a feature of the New Zealand market considering its size and location. If one major producer or supplier was disrupted, many retailers would also be inconvenienced as that supplier is a single point of failure.

Supply web vulnerabilities mean that there is also a pre-disaster requirement for organisations to understand the minimum conditions to maintain core business functions. Minimum requirements being the least possible requirements for the organisation to function. Also, prior understanding of the availability of external resources, i.e. from outside the organisation, is

important. This is of course situation, industry sector and business type dependent. The robustness and resilience of an organisation's supply web are only some facets of this. Also of value is recognition of the critical links in the supply web as well as understanding how these links being disrupted would affect the members of the web.

9.2.7 Limiting factors (resources)

In every system there are limiting factors. In the presence of all other resources, limiting factors act to slow down the functioning of a system or its subsystems. For recovery, this is not always a good thing. In greater Christchurch, depending on which part of the system is under scrutiny, there were several such factors. They include finance, skilled labour, infrastructure availability and recovery plans, among others. For instance, the lack of a somewhat detailed recovery plan resulted in difficulty for organisations and sectors, e.g. building suppliers, in forecasting demand. This then affected the supply side also.

9.3 Points of intervention in recovery: From research to practise

From the analysis above, there are points of intervention in the system where action can be taken in order to alter the trajectory and influence the system. Meadows (2008) calls these *leverage points*. The identification of these points in the system is one of the ways in which this research can make a practical contribution for the benefit of policymakers, organisations and sectors. This is in addition to clarifying why the system behaves the way it does. It should be noted that the system can be influenced in a positive or negative direction depending on the motives of the intervener.

The aids and hindrances to recovery as well as the discussion in chapter 7 shows that from an organisational and sectoral perspective, there are three main aspects that interact and lead to different degrees of vulnerability. These three aspects are: the organisational characteristics, infrastructure and frameworks used by organisations to deliver goods and services, and ecological factors which are outside the control of the organisation. In conjunction with analysis from chapters 5, 6 and 8, these are the aspects that will be used in discussing points of intervention. In this chapter, the points of intervention in recovery have been grouped into: actions by organisations and sectors, infrastructure used by organisations and environmental factors.

9.4 Actions by organisations and sectors

The decisions made by an organisation in the immediate aftermath of disaster can influence not only their long-term recovery but that of other organisations. Corey and Deitch (2011) came to similar conclusions when they investigated organisational recovery after Hurricane Katrina.

9.4.1 Investment in staff

The realisation that staff are crucial to the organisation and its recovery after disaster should translate into organisations investing more in their staff, for example through training, counselling, the enablement of employees to balance family and work demands. This investment needs to be done both before and after a disaster event.

For instance, information from organisations shows that the ongoing earthquakes in Canterbury took their toll on staff and their families. Organisations reported that on return from the Christmas and New Year break 2011 - 2012, employees seemed more tired than before they went on break. This is likely because of additional earthquakes and also from other earthquake effects such as filing insurance claims and dealing with tradespeople. These activities dragged on from one month to another in a seemingly endless cycle and took their toll on people's reserves. The multiple earthquakes worked to reset the clock (physically and emotionally) for many people and for some, affected their performance at work. Some organisations reported that actions such as making sure staff took some time off were helpful.

9.4.2 Organisational or sectoral leadership in crisis and leadership wellbeing

Another element necessary for successful recovery is leadership. This is touched on in chapter 6. Staw et al. (1981) observe that in situations where the organisation faces an *external threat* (e.g. an earthquake) people in an organisation will look to others in the organisation in positions of leadership for direction. From the definition of organisational crisis given in chapter 2, it can be concluded that leadership is needed for all crises.

The case study organisations all narrated the importance of having a thoughtful, decisive, goal oriented and clear communicator as one to lead a crisis. This is the person or persons that initially assess the altered post-disaster environment before the organisation can open its doors

again. This means there needs to be an awareness of what has transpired and what is yet to unfold. Another aspect of leadership is to plan for and implement the targeted and effective[46] use of resources in the response and recovery phase so that available resources are put to the best use during response and recovery. Specific to the greater Christchurch region, in the presence of other resources (financial, physical and geotechnical engineering knowledge), persistent earthquakes should only affect the decision making for so long.

However, the interviewer observed that the wellbeing of the small business owner and of the people in organisations leading the recovery is something that needs to be explored further. People leading the recovery effort were themselves affected by the earthquakes. This may or may not have had a bearing on how they led. Specific to the small business owner is that they are the business and the business is them. Small business owners should look into possible succession plans for crisis times as they have to manage their personal as well as professional lives with little or no outside help.

9.4.3 Investigation, analysis and application of lessons

Recovery starts before or immediately after an event in the measures taken by organisations to prepare for and mitigate against the outcomes of disaster. At the time of interviewing (March to April 2012), most of the organisations had not reviewed decisions and actions that were taken in the response and early recovery phase after each earthquake. As is discussed in section 5.5, organisations may overestimate how well they performed both during and after the response and very early short-term recovery phases post 4 September 2010. This may have affected analysis of their response, in how well they coped, as well as subsequent preparation for future disaster response. Paton et al (1998) write that this magnification of the organisation's capabilities after surviving one disaster may have an effect on how well the organisation prepares for future events by underestimating risk and by constraining thinking. Mileti and O'Brien (1993) refer to this as *normalisation bias*.

It would be helpful for organisations to have an organisation wide discussion of response and recovery actions and decisions, not for the purposes of finger pointing or individual blame but to identify best practise that can inform corporate strategy as well as possibly reducing or

[46] Effective here means that the planned and eventual outcomes are the same.

counteracting future crises or disasters. Some of the ways in which organisations can do this is by enquiring if the organisation's existing (institutional) capabilities are adequate for the handling of future challenges or if there is a need to modify and add to these capabilities. For instance, for the building suppliers sector, will the sector have the resources to deal with the requirements of rebuild when it takes off on a large scale?

For all sectors, some of the lessons learnt can be applied as soon as is possible in the recovery process. For example, there should be an emphasis on building back with improved methods and technologies. It appears that experiencing losses in the earthquake had a positive effect on the preparedness levels of some organisations in this study. The *two* items on the preparedness checklist that showed the greatest improvement following the earthquakes were bracing of shelves and equipment, as well as having the organisation's premises structurally assessed.

9.4.4 **Preparedness for all hazards**

Crisis preparedness is linked to the analysis and use of lessons from prior crises. In crisis preparedness, most of the organisations spoken to did not have documented crisis, emergency or business continuity plans over and above fire evacuation maps and fire extinguishers. Additionally, some organisations reported also not having back-ups of important organisational information. And yet the large majority were able to adapt to the turbulent circumstances, recognising in the process what they had to do to carry on in the short- and long-term. This is good but adaptability is only one of the elements in the successful recovery of a firm. Preparedness and planning should be ongoing; these activities do not end with the production of a written report. Organisations observed that in hindsight, pre-existing crisis plans and the rehearsal of these plans (table top and enacted) are good starting points for how to manage in crisis. Enacting plans not only ensures that the people who use these plans know of their existence but also that they know what is contained in the plans. Organisations further noted that as every crisis is different, crisis, emergency, business continuity or recovery plans should contain enough detail to act as a guide but not too much detail that there is little room to adjust.

There are also other aspects to disaster preparedness. One crucial part to incorporate into the design of disaster planning is the behaviour of people in the organisation in reaction to a disaster. For instance, after the earthquakes, one organisation noted that they had good

evacuation plans but no mention of re-entry plans which is one part required for business continuity in their case.

Other preparedness measures include the organisational development of robust back-up practices for all important documentation. This is to mean more than one extra copy of any vital information as well as storage in different formats and locations. Back-up can also be for machinery or premises by having mutual aid agreements with other organisations. Preparedness can also involve organisations investing in new building technologies for damage avoidance to mitigate against damage and disruption.

Preparedness includes the organisations incorporating disaster resilience into their strategy. For most organisations the expenditure on crisis preparedness needs to be balanced with the value of those plans both before and after disaster. As there was concurrence on the value of resilience and its attendant benefits to organisations, there is a business case to be made for resilience. Organisations should look into investing in those actions that would make them resilient such as succession planning, having good leaders, well trained staff as well as emergency and recovery plans. Chapter 10 touches on this by analysing how organisations can embed disaster resilience and make a business case for the same.

A relatively high proportion of organisations engaged in some measures geared towards life-safety, such as having a first aid kit and fire extinguisher available on their premises. Organisations however reported that they were not prepared for large events such as the Canterbury earthquakes. This is a demonstration of organisations being prepared for events they thought would happen to them and not a broader range and scale of hazards. Rather, organisations should engage in planning from an all-hazards perspective as it is not possible to plan for every single possibility. Generic plans have the advantage of being applicable to many different hazards and scenarios. For the organisation, such plans also save them resources as they spend considerably less time and money developing all-hazard plans than specific hazard plans.

In risk management exists the *principle of consistent crudeness* (Elms, 1985) which organisations can use as a heuristic for disaster preparation. Using this principle, the amount of effort or energy put into any one part of disaster readiness should be commensurate with that in other parts of

the readiness strategy or plans. This is because disproportionate attention to any one part could equal a poor utilisation of resources if there are weaknesses in other parts.

9.4.5 Involvement of organisations and sectors as part of the core recovery strategy

Results from this study have brought to light that organisations and sectors can engage in recovery in various ways: as employers, as stakeholders in the community and as an aid to each other's recovery. In this way, they can be used as leverage points in recovery. From the actions that organisations took to aid employees, and also collectively because of the number of employees they have, organisations are an integral part of any disaster response strategy. First, organisations have access to a large number of people at the same time. They also usually have resources available to employees that can help the community at large. Apart from their being monetary contributors to the recovery effort they can be used in response, recovery and mitigation phases to reach communities and help the authorities collect critical information e.g. by collecting information on the state of employees houses and sending this into a central recovery database. This could work in conjunction with the Red Cross and other organisations and act to inform decisions about where help is most needed and what actions need to be taken.

This approach is not without its drawbacks. First the location of the disaster would play a major role. In the case of Christchurch, the nature of the disaster and the availability of technology meant that a lot of employers embarked on ascertaining the wellbeing of employees and families. This method might not be applicable in a less developed country or in a larger disaster or catastrophe. Also, there would have to be guarantees of privacy for the information provided. After the earthquakes, employees were more willing to give out certain types of personal information though, such as private or unlisted telephone numbers and other data that could be used for recovery purposes. For employers in Christchurch, this was information they were already collecting anyway from their employees to help them decide what kind of assistance they could provide to employees. For example, one organisation booked holiday homes in Hanmer Springs, an area close to Christchurch. All the employees and families who were still in Christchurch were strongly encouraged to use it on a rotational basis. Despite this, the recovery authorities would still have to be aware of those who are unemployed and have no access to communication facilities.

Organisations also found value in sharing best practice on how to manage employee stress or on parts of recovery strategies employed (inter- and intra-sectorally) by other organisations within and outside their sector. This is an example of pooling the knowledge of a few into the work of many others and saving resources such as time and money. After all, the different organisations and sectors are to various extents dependent on each other for recovery. However, for the long-term recovery strategy of the greater Christchurch area, organisations reported that they were not consulted on what they thought or were not asked to *sit at the table* especially considering the interests (financial, human, etc.) they had in the recovery of the area. This is the under- or non-utilisation of resources.

9.5 Infrastructure used by organisations

From the effects of the earthquakes, two things are important for organisations to look for; the causes of disruption and the effects of disruption. This should also be applied to structures organisations rely on for delivery of goods and services.

9.5.1 Physical infrastructure

This is infrastructure organisations are dependent on to produce and deliver their goods and services. This includes but is not limited to roads, bridges, plant, machinery, communications apparatus (computers, telephones, and radios), water and electricity. The organisation's inability to access or use this infrastructure can cause disruption to operations. In the greater Christchurch context the extensive building damage was limited to specific areas and the restoration of critical services such as electricity and roads was relatively quick. The quick restoration of essential services is a leverage point in recovery. Additionally, the arrangement of the rubbish transfer stations, in Christchurch, enabled the removal of debris from building and demolition sites allowing organisations that could, to re-enter premises and in some cases resume operations. The presence of debris can cause disruption by limiting access to infrastructure.

9.5.2 Supply web

The supply web forms part of the organisation's network. After disaster, a functioning supply web is another leverage in recovery. This may enable an organisation to restart operations quicker. This is discussed further in section 9.1.5.

9.6 Environmental factors

In any disaster, but especially on a regional or wider scale, organisations are affected by agents in their environment. As elements in larger systems, organisations operate in an environment where the actions they take and the results of those actions are sometimes dependent on the actions and decisions of others such as customers, suppliers, competitors or the authorities. Therefore, there are points in the organisation's or sector's environment that can be used to effect recovery.

9.6.1 Role of recovery leaders and agencies

The significance of the people and the agencies leading overall recovery efforts cannot be overestimated as a leverage point in recovery. A competent, inspired and inspiring leadership to set the recovery goals and come up with an overall recovery strategy gives vision and hope to all interested parties. This also ensures that all agents involved with the recovery, to whatever extent, can align their plans with the greater recovery strategy. However, apart from the effort put into aligning stakeholders towards the same goal, the goal has to be the right one, as defined by the stakeholders (see section 8.4.5).

Interviewees spoke of the silos between the main organisations or authorities working towards or leading the recovery. These were the Canterbury Earthquake Recovery Authority (CERA), the Christchurch City Council (CCC) as well as other government agencies. The silos contributed to the authorities not sharing valuable information with each other about the recovery strategy. Often, one agency did not know what the other was planning which led to different groups being given conflicting information. It also caused confusion about who really was in charge of recovery for greater Christchurch.

In all, organisations identified the stakeholders in recovery after the earthquakes as CERA, local authorities, communities and organisations (the business community). Even after the link between business and community was identified (see section 6.6), organisations reported that they still did not work with the other recovery stakeholders in a way that was more beneficial. This shows that in managing after disaster, it is not necessarily a command-and-control

approach[47] that is required. What should be emphasised is the coordination between different stakeholders.

From the contextual interviews and case studies, some respondents expressed dissatisfaction at the structure of CERA. The setting up of a Recovery Authority to lead the work was welcomed but the direct report of its Chief Executive to a government minister was not. Interviewees felt that reporting to an independent board would have given the Recovery Authority more autonomy and that it would have engaged better with the community and with organisations. Some of the reasons for this were that the way Central Government functions, and by extension CERA, was not the best way to guide such a massive and sensitive project. It was felt that reporting to a government minister disempowered the organisation and by extension the people of Christchurch in what was for them a very personal recovery. It remains to be seen whether the setup of CERA was the best alternative for recovery after the Canterbury earthquakes.

9.6.2 **Regional and national economies**

After disaster, one goal of a Recovery Authority should be to encourage the creation of conditions conducive to successful recovery. In this way, a regional or national economy can be used to leverage recovery. For instance, the creation of a special category visa for personnel with skills required for the Canterbury earthquake rebuild was one such point of intervention.

9.6.3 **Information**

Organisations require information in order to make meaningful strategic plans for instance. After disaster, the content of information communicated is essential. See section 9.2.3 for more detail.

9.6.4 **Communication**

Information and communication are complementary. The dissemination of information relies on the means of communication. The importance of this after disaster is discussed in section 9.2.3.

[47] A command and control approach may be required in the immediate response.

9.6.5 **Policy**

Policy is another tool that can be used to influence how the system behaves. However, the direction of influence is not always as intended. For example, it was recognised that transportation of disaster debris to pre-earthquake transfer stations led to delays in carrying out demolition on demolition sites. Organisations involved in debris removal were then allowed to sort waste on the demolition site or from temporary transfer stations in order to hasten demolition and access to sites. In some cases, this led to some organisations removing financially valuable parts of the debris, leaving the not so valuable parts to be cleared up by someone else, in this instance the taxpayer. This behaviour affected the organisations that sorted all their waste as they had a smaller profit margin than the rogue waste removal organisations. The actions to stop these rogue businesses were seen as ineffective. For laws to work, they must be seen to be fair.

A case where policy did not work so well is with CBD Red Zone cordon. The cordon was set up to keep people out of the damaged CBD area and safe. Organisations whose premises were in this zone required access in order to retrieve stock and documents as well as for insurance purposes. However, there was a consistency problem in that some people were let into the Red Zone while others were not. There was a lack of communication between CDEM and CERA and organisations needing to access the Red Zone. In addition, there was no proper explanation or information for why this was so or when organisations could access their premises. Organisations reported that this led to corruption in who got into the zone and who was excluded. This was in addition to the looting that had taken place in some parts of the cordoned off area.

Policy can also be used as input into the building code for seismic limits for new buildings or for the reinforcement of older building stock. Other possible policy measures proposed after the Canterbury earthquakes were moratoria on new hospitality or retail licenses for a period of five to 10 years as a way of assisting the struggling hospitality and retail sectors. This is very similar to offering subsidies to organisations and has some of the same disadvantages. It can be argued that if some of these organisations were not doing well prior to the earthquakes then they should not be assisted in this way after the earthquakes. Instead, conditions such as increasing tourist or

customer numbers should be created that encourage these organisations to flourish. The moratoria in and of themselves may stop start-ups but will not bring much needed customers to existing establishments. Alternatively, the timescale for the moratoria needs to be considered carefully if it is to be part of the overall recovery strategy.

9.6.6 Subsidies and incentives

The Earthquake Support Subsidy (ESS) provided by the Central Government was welcomed by just about everyone affected by and involved in the recovery of greater Christchurch. Other incentives mentioned in interviews included lower land rates for building owners wanting to re-invest in the Christchurch CBD.

However, some interviewees felt that in place of subsidies or incentives should be the creation of conditions that attract the return or setup of organisations and people to an area like Christchurch's CBD. These could be to do with the architecture of the buildings or the activities that people could engage in.

9.7 Critical success factors for organisational and sectoral recovery after the 2010-2011 Canterbury earthquakes

In summary, the management of the recovery process after disaster can be compared to that of managing a project in the business sphere. Therefore, the project management principle of *critical success factors* (CSFs) (Rockhart & Bullen, 1981) is pertinent to disaster response and recovery. CSFs are factors essential for a project to achieve its aims. In disaster response and recovery, CSFs are those actions that must work out well or elements that must be present if the recovery efforts are to succeed.

There are numerous CSFs in recovery from disaster. In chapters 4 to 7 of this thesis, the differential effects of disaster for different sectors are shown. Consequently, it stands to reason that the CSFs for the sectors in this study may differ by sector while others may be similar. For instance, just after the earthquakes, the critical infrastructure sector was in need of spare parts for repair while the building suppliers sector was in need of information required for forecasting. However, for both sectors the CSF of leadership is important. Table 9-1 shows the CSFs that have been identified for the recovery of the sectors in this study. The CSFs with the √ sign are

what contributed positively to recovery of the sector. The CSFs with the X were important but were, from the organisational and sectoral perspective, either missing or not done well.

Table 9-1 Sectoral critical success factors that contributed positively to recovery:

	Buffers							**Adaptation**					**Information and communication**	
	Accommodation	**Stock (spare supplies)**	**Earthquake Support Subsidy (ESS)**	**Organisational networking**	**Road network disruption**	**Supply of resources (skilled personnel, machinery)**	**Location of customers**	**Relocation**	**Mode of delivery of goods and services**	**Other forms of adaptation (e.g. site sharing)**	**Leadership**	**Staff**	**Internal**	**External (with recovery agencies)**
Building Suppliers											√	√	√	X
Critical Infrastructure		√		√	X	X			√		√	√	√	X
FMCG		√		√	X						√	√	√	X
Hospitality			√		X						√	√	√	X
ICT	√		√		X	X	√	√	√		√	√	√	X
Trucking					X	X			√		√	√	√	X
Christchurch CBD	√		√		X	X		√			√	√	√	X
Kaiapoi Town Centre				√	X						√	√	√	X
Lyttelton Town Centre			√	√	X					√	√	√	√	X

The CSF all sectors deemed important but deficient was that of external information and communication with recovery agencies. This is related to the identification and engagement of all stakeholders in the recovery process, arrangements on the cordon around the CBD and the general uncertainty not reduced when there was no information forthcoming from recovery agencies. Road network disruption is another CSF particularly pointed to by all sectors. This is attributable to the need for critical infrastructure organisations, for example, needing to get to repair sites, customers not being able to reach organisations, organisations not being able to reach customers, increased amount of time on congested roads and increased vehicle maintenance costs from wear and tear caused by driving on damaged road infrastructure. For critical infrastructure, ICT and trucking, a shortage of resources in the form of skilled personnel

to carry out work affected the sectors. Trucking and Christchurch CBD were affected by availability of specialist machinery for building demolition and deconstruction.

In this study, CSFs are applicable to both organisations and sectors. To gain the most out of CSFs, organisations and sectors need to identify, at the earliest opportunity, those activities crucial to the success of their recovery and then carry them out. It should be noted that some CSFs might not be immediately apparent in the aftermath of disaster and that these CSFs change the further in time from the disaster event. For instance, from the project management literature, Pinto and Prescott (1988) write that the different stages of the project life cycle have different CSFs. For organisational and sectoral recovery after the Canterbury earthquake sequence, this is demonstrated in the different feedback loops dominant at different points in the system's time horizon.

9.8 Chapter summary

In this chapter, the use of system dynamics has enabled the identification of the aids and hindrances to recovery as well as points of intervention in the system. This was done by observing the effects of the interactions between system actors. Knowing the possible sources that have an influence on recovery and at what point in the recovery timeline will better inform policy decisions, lead to the improvement of loss estimation after disaster and increase overall organisational and sectoral resilience. Recovery research should therefore give more priority to what organisations and sectors require for a successful, long-term recovery and reconstruction.

Essentially, it is not easy to place the aids, hindrances and point of intervention in recovery in rank order. This is because, as has been pointed out previously, each sector was affected differentially and also every disaster is different. Additionally, from the systems perspective, different feedback loops are dominant at different times and act to influence the system in different ways. Elms (1985) in his principle of consistent crudeness cautions against concentrating on one element to the detriment of other elements which are part of the system.

After a disaster event, the list of aids, hindrances and points of intervention can be used as a starting checklist for how the organisations and sectors have been affected, what is required for their recovery and the importance of each of these requirements at the different points in time

after the disaster event. These can be used in conjunction with the signifiers of recovery and the critical success factors for preparation before a disaster and for recovery after.

Based on the contextual interview and case study data (chapters 4 and 6), survey data (chapter 5) the signifiers of recovery (chapter 7) and the systems analysis (chapters 8 and 9), it is possible to classify tier 1 and tier 2 influences that affected the recovery of Canterbury organisations. Tier 1 indicates that these influences had greater import than tier 2. It is also important to remember that the Canterbury earthquake sequence was a regional disaster. Therefore, the more influential elements in this disaster may not be the same in a disaster in a different place or of a different scale. These tiers can also be used as information by organisations and recovery agencies outside the Canterbury region to help them prepare for and manage disaster.

Tier 1 influences:

- → Staff capability and wellbeing;
- → Availability of resources (skilled workers, machinery, finance, stock, utilities);
- → Demand for organisation's or sector's good and services;
- → Uncertainty, information and communication;
- → Leadership;
- → Location of customer base;
- → Mode of delivery for organisation's goods and services; and
- → Localisation of earthquake damage;

Tier 2 influences:

- → Organisational level characteristics e.g. preparedness and documented crisis plans ; and
- → Organisational location.

In chapter 10, organisational and sectoral disaster resilience will be explored. Specifically, what aspects contributed to organisational and sectoral disaster resilience after the 2010 – 2011 earthquakes in Canterbury.

10 Sectoral and organisational disaster resilience

In chapters 6 and 8, it was demonstrated that there are three broad categories whose elements combine to varying degrees making organisations susceptible to disaster. These are the organisation's internal characteristics (e.g. type of goods and services delivered, preparedness and planning), the physical systems involved in the delivery of the organisation's goods and services (e.g. roads and equipment) and the organisation's environment (e.g. community hazard mitigation). In addition, the extent to which an event causes disruption is dependent on the scale of the event: whether it is an emergency, crisis, disaster or catastrophe. In the disaster literature, Quarantelli (2006) writes about the magnitude of an event leading to its classification in one of the categories.

Consequently, for the regional disaster that organisations in Canterbury found themselves dealing with, this work puts forward the thesis that there are at least two interconnected levels of resilience. The first is the *business-as-usual* (or pre-disaster) resilience of the individual organisation and to a degree that of its sector. This is related to the organisation's characteristics such as finance, location and type of goods and services. The second level of resilience is to do with the environmental factors emergent after the Canterbury earthquakes and necessitates the development by organisations of their *disaster resilience*. The connection between the two levels of resilience is depicted in Figure 2-6 in chapter 2.

The reason for the distinction between these interconnected levels of resilience is to do with the scale of an event. Business-as-usual resilience is when the organisation is affected but little or none of its environment is similarly affected. Disaster resilience is when not just the organisation is affected but also its environment such as suppliers, customers and the community. The interaction of these two levels of resilience typifies the hierarchy of systems within systems. Authors such as Paton and Johnston (2006), Tierney (2008), Manyena (2006), Chang (2004), Alesch and Holly (2002), Whitman et al (2011) as well as Kachali et al (2012)detail how the concept of disaster resilience has gained prominence and is vital for recovery after disaster.

In addition to business-as-usual organisational resilience, organisational disaster resilience was also required for organisations affected by the Canterbury series of earthquakes. For instance, some organisations from the critical infrastructure sector pointed to their being well prepared to handle crises that are part of their business-as-usual but that this preparation

(and resources) was not always adequate for the work needing to be done after the earthquakes (see chapter 6 for details). In the FMCG sector, organisations narrated being affected because the populations they served were affected. For some FMCG organisations this was in the form of the community moving away leading to reduced custom while for other FMCG organisations this took the form of increased customer numbers. And yet, this was only one element that affected FMCG organisations in their recovery after the earthquakes. From chapter 8, it is shown that there were many more interactions, such as product supply disruption, that had a bearing on FMCG recovery. Consequently, after the Canterbury earthquakes, it was evidenced that disaster resilience incorporates many more facets than business-as-usual organisational resilience in the breadth of agents both affected and involved.

A further representation of the need for organisational disaster resilience is staff wellbeing and its link to external organisational elements such as the wellness of staff family, friends and community. The wellbeing of the community is also connected to hazard mitigation decisions made by the community and which affect the recovery of organisations post-disaster. For instance, the decision made by elected officials to under-insure public buildings partly contributed to how organisations from the Christchurch CBD and town centres in the study were affected. Also, the unreinforced masonry (URM) buildings in the CBD and town centres were especially vulnerable to earthquake shaking which led to extensive damage and extended periods of closure for these areas.

Another agent involved was New Zealand's Central Government which created a ministerial position as well as an agency (Canterbury Earthquake Recovery Authority - CERA) especially dedicated to the recovery of the region after the damage caused by the 22 February 2011 event. Therefore, in a regional disaster, organisational disaster resilience plays a larger role than business-as-usual organisational resilience. Importantly, for both levels of resilience, baseline indicators are required for measurement and monitoring especially across time.

As illustrated in chapter 5, one part of each survey deployed for this study contained items from the Benchmark Resilience Tool[48] (BRT-53 or BRT-13) as a measure of organisational resilience. Using computations from these items after Surveys 1 and 2, the BRT

[48] BRT-13 is the short-form version of the BRT-53. See (Z.R. Whitman et al., 2013) for development of BRT-13. In this thesis, *BRT* is the umbrella name for both BRT-13 and BRT-53.

organisational resilience indicators which were more prominent for each sector are presented in this section. Also, participants in contextual interviews and case studies were asked to describe resilience (see chapter 6.5.4). The more prominent indicators of disaster resilience deduced from the interviews and case studies are also presented here. The two sets of resilience indicators, from the BRT-53 and BRT-13 as well as from interviews and case studies, are contrasted. This section also contains discussion on the relationship between recovery after disaster and the organisation's or sector's level of disaster resilience.

10.1 Sectoral disaster resilience indicators - using the Benchmark Resilience Tool (BRT-53 and BRT-13)

The Benchmark Resilience Tool (BRT-53) (Lee, Vargo, & Seville, 2013; McManus, 2008; Stephenson, 2010) was developed to be used by organisations to measure their resilience. For example, many of the items in the BRT address how respondent organisations run their day-to-day business, preparedness measures they may have engaged in and how *they would* respond in a crisis. The organisations in this study used the BRT while in the midst of a crisis at a regional scale and the BRT does not specifically ask about organisational actions in a regional disaster. However, even in a regional disaster, some of the responses to the BRT yield possible understanding into what is required for organisations and sectors to be disaster resilient. Appendix F contains the complete tables for BRT sectoral resilience scores and for the items contained in the BRT.

As this research sampled the same group of respondent organisations multiple times, it can be likened to a longitudinal study. The same questions from the BRT were asked of respondents at three different points in the course of the research. Additionally, the effects of the 4 September 2010 and 22 February 2011 earthquakes are considered in analysis. For instance, it is likely that the BRT organisational resilience scores after the 22 February 2011 earthquake are a result of organisations being more affected by environmental factors than by those inside the organisation (see chapters 5 for BRT scores and chapter 8 for environmental factors).

Diggle (2002) writes that a fundamental advantage of longitudinal studies is in how they effectively measure changes over time in the same variables. Also, because of the involvement of multiple respondents in the study, the findings can be generalised. Diggle also points out that in some studies, the period, or calendar date is also essential in analysis. Harter et al (2006), in their study on the administration of surveys amidst disaster,

demonstrate how a disaster event can affect respondents as well as survey results. Anderson (1969) shows how organisations undergo periods of adjustment post-disaster that affect how they function. In the case of organisations in Canterbury, the effects of the earthquakes most likely had a bearing on how they responded to survey questions.

It has been demonstrated how the sectors in this study were affected variably after the Canterbury earthquakes. It follows that the sectors in this study had different sets of individual BRT indicators that were more meaningful for them. Table 10-1 shows the differences in sectoral resilience indicator scores between Survey 1 (deployed after 4 September 2010) and Survey 2[49] (deployed after 22 February 2011). For each sector the three largest differences (decreases) in sectoral resilience indicator scores are shown in **bold** font. The organisational resilience scores from Survey 1 are comparable to those from Survey 3. As well, the sample set in Survey 3 is smaller than in both Surveys 1 and 2. For these reasons, it was deemed sufficient to use BRT organisational resilience scores for Surveys 1 and 2.

The current design of the BRT uses the concept of *the higher the overall organisational resilience score, the more resilient the organisation*. This is the same for the organisational resilience individual indicator scores. Therefore, the difference in the BRT organisational resilience score achieved by the organisation can be compared to the highest possible score as a means of evaluating performance. The results can thereafter be used to improve resilience. Similarly, in existing organisational practices, the balanced scorecard (BSC) developed and popularised by Kaplan and Norton (1992, 1996b) is used to set organisational priorities such as staff or customer satisfaction and the targets for those priorities. At the end of the measurement period, the target and the actual values are compared as a means of checking how well the organisation performed. The differences in scores are used to set improvement measures. In the same way, the Australian Bureau of Statistics (ABS) (2012) runs the annual Business Longitudinal Study (BLS) for employer organisations. The annual BLS measures the impact of different business characteristics (e.g. industry sector, exports and employment details) and uses this change in metrics to track the performance (e.g. profit, revenue and sales) of businesses. From a systems point of view (see chapter 8), the negative feedback loop depicting disaster recovery shows how organisations can use the differences between their actual and intended targets to draw up organisational improvement measures.

[49] Lyttelton organisations did not take part in Survey 1; the prominent indicators for those organisations were calculated using Survey 2 and Survey 3 data.

In the same way, in this study the difference in sectoral indicator scores between the two surveys shows which of the indicators of resilience the respondents were more affected by or were more sensitive to in the case of a regional disaster. Kaplan and Norton (1996a) as well as Davenport and Stoddard (1994) advise that it is more useful for organisations to concentrate on diligently pursuing a few aspects and doing those well as opposed to working on a broad suite of organisational improvement measures and not doing them well. This is the fundamental reason for this study highlighting the three sectoral resilience indicators that showed the largest differences between surveys 1 and 2. Furthermore, three indicators linked to the organisation's strategic goals are a more manageable objective that individuals in the organisation can focus on at one time as opposed to 13 indicators.

*Table 10-1: Percentage differences in Benchmark Resilience Tool (BRT) sectoral resilience indicator percentage scores between Surveys 1 and 2**

Percentage differences* in Benchmark Resilience Tool (BRT) sectoral resilience indicator percentage scores between Surveys 1 and 2 (all values are in percentage %)													
	Planning Strategies	**Participating in Exercises**	**External Resources**	**Recovery Priorities**	**Proactive posture**	**Leadership**	**Staff Involvement**	**Situation Monitoring & Reporting**	**Minimisation of silos**	**Internal Resources**	**Decision Making**	**Innovation & Creativity**	**Information & Knowledge**
	P1	**P2**	**P3**	**P4**	**P5**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**
Building Suppliers	8	2	-3	14	**20**	**25**	**29**	6	18	18	16	9	6
Critical Infrastructure	28	**37**	**36**	32	28	27	**35**	29	24	32	27	23	24
FMCG	19	16	16	25	25	28	**32**	28	28	**34**	**41**	25	19
Hospitality	28	21	10	23	5	**37**	25	25	**33**	26	**30**	22	16
ICT	15	10	3	0	5	24	**28**	19	**33**	**26**	22	23	9
Trucking	21	13	13	14	20	**32**	**30**	20	23	25	**29**	27	17
Christchurch CBD	13	14	22	15	12	**24**	**31**	15	22	**24**	**27**	16	11
Kaiapoi Town Centre	13	19	8	3	6	16	18	13	**25**	**22**	**22**	**22**	4
Lyttelton Town Centre	15	13	**25**	15	16	12	9	**27**	13	23	10	**28**	-5
Entire Sample Group[50]	19	17	14	14	14	**28**	**27**	21	**28**	**27**	**27**	23	13

**All positive numbers, i.e. positive percentages, indicate a decrease between Surveys 1 and 2 while negative values indicate an increase from Survey 1 to Survey 2*

[50] As these results are using Survey 1 and Survey 2 results, the Lyttelton sample is not included as they did not take part in Survey 1.

Therefore, the prominent indicators highlighted in Table 10-1 may serve as an aid in development of disaster resilience measures for the organisations and sectors in this study. Also, as the indicators of resilience are interconnected, work on some of them may lead to some improvement in others. Also, from chapter 8 and manifested in the difference in organisational resilience scores between Surveys 1 and 2 is the concept that resilience advancement is context dependent and is a continuous process.

The analysis that follows in this chapter is based on information from the qualitative data provided by organisations; the organisations were not specifically queried on their interpretation of the items and indicators contained in the BRT-53. This information was obtained from organisations while pursuing other lines of questioning to do with disaster recovery. This is another reason for discussing only three indicators per sector. The detailed explanation for all the indicators requires a thorough investigation in which they are the focus. Consequently, each organisation and sector may have distinct explanations for how the indicators relate to them. This is an area that could be pursued further in future research coupled with follow on surveys of earthquake affected organisations at four, eight and 10 year intervals from the 4 September 2010 earthquake.

10.1.1 Sectoral indicator score differences - overview

When broken down by sector, the BRT indicators: planning strategies, recovery priorities, and information and knowledge did not feature at all for organisational resilience indicators that stood out in disaster. Analysis of the items (questions) that form the BRT indicators (see appendix F for a list of the BRT-53 indicators) shows that some of them may not necessarily apply in the context of a disaster.

Organisations reported that after the earthquakes, they tried to understand the situation, how they had been affected and that uncertainty was the norm and not the exception. One of the items making up the planning strategies indicator asks about *planning strategies carefully before taking action*. *Carefully,* in this instance, to mean cautiously or after thorough assessment. However, in the immediate aftermath of a disaster, a lot of instinct and adaptation is called for and is partly dependent on availability of information and resources. Post-disaster, information and resources are not always readily available and some decisions have to be made on the spot with whatever information is at hand. In disaster, it is not always possible to completely assess a situation before reaching a decision.

The information and knowledge indicator is also not one of the three prominent indicators for any of the sectors. Survey and interview respondents stated that one of the most important elements in recovering from disaster is information that is credible, timely and relevant to the situation. One of the items from the information and knowledge indicator asks about *readily obtaining expert assistance when there is a problem*. The supply of expert assistance, e.g. geotechnical and structural engineers, was not in step with the increase in demand especially after the 22 February 2011 earthquake. Additionally, with the huge uncertainty caused by the earthquakes as well as other interacting factors, in the response and early recovery phases it was not easy for organisations to tell what the problem actually was let alone get expert assistance.

Furthermore, one of the recovery priorities indicator items is *we understand the minimum level of resources our organisation needs to operate*. All organisations interviewed expressed that they knew what minimum resources their organisation needed to operate during business-as-usual. However, their operational needs after the earthquakes differed from business-as-usual and it was not always immediately apparent what the requirements were as they adapted to a changing situation. As demonstrated in chapters 6 and 8, base requirements to keep the organisation operational are different in a regional disaster and at different times after the disaster event. As well, keeping the organisation operational in the response phase in efforts to minimise further damage differs from the short-term phase when resumption of productivity may be the focus.

As stated earlier, any future study of the BRT, for disaster, needs to incorporate detailed scrutiny of both the questions and the indicators. There are two main reasons for this. The first reason is that there are indicators, e.g. planning strategies, which after the earthquakes were not among the most prominent for any sector. Further investigation may reveal which indicators are applicable in a disaster context. Additionally, analysis of all items in the BRT-53 showed that even for indicators that were outstanding for some sectors, not all the questions applied in disaster. More extensive and detailed research of the indicators and items in the BRT is required and recommended as a future research strand.

10.1.2 **Building suppliers**

Apart from staff involvement and leadership, proactive posture was one of the indicators with a more significant difference for building suppliers. In fact, this was the only sector where this indicator was prominent. One of the sector's biggest challenges after the

earthquakes was the inability to forecast demand as the rebuilding boom that was expected to occur did not. One of the other effects of the earthquakes was that work that had been scheduled pre-earthquake, for example home renovations, was put on hold or cancelled because of earthquake damage and insurance wrangles. Some of the building suppliers expressed that they had taken a wait and see approach for when their sales and revenue would pick up.

10.1.3 **Critical infrastructure**

Two of three noteworthy indicators for critical infrastructure were to do with planning: participating in exercises and external resources. As discussed earlier, this was the only sector where all organisations had pre-earthquake crisis or emergency plans. Organisations in this sector also believed that not only should these plans be documented but that they should also be tested. Critical infrastructure organisations reported regular practise drills as part of their business-as-usual and that this helped in the response phase. Despite planning and rehearsing their plans locally, critical infrastructure organisations reported that the scale and urgency of the task required the use of staff from offices outside Christchurch as well as contractors from other organisations.

Critical infrastructure organisations also had to work with many other organisations in the response phase. Some of these organisations were parts suppliers who at times did not have required stock on hand. This affected critical infrastructure's perception of external resources. The third prominent indicator was staff involvement. Of all the sectors, staff from the critical infrastructure sector worked the longest hours restoring and repairing time critical services after the earthquakes. The sector reported that one of their biggest challenges was managing staff work times and workloads in addition to ensuring people had enough rest between jobs and that they got the chance to look into personal matters.

10.1.4 **FMCG**

The three outstanding indicators for FMCG were staff involvement, internal resources and decision making. FMCG organisations reported that they required more staff after the earthquakes for the large clean-up work that resulted from damaged shelving and stock loss. Organisations also reported that they did not have adequate stocks on hand for some goods such as bottled water which were in higher demand after the earthquakes. The decision making indicator can be attributed to resolving what product mix was right after the

earthquakes as some products were more in demand than others. In reaching some of these stocking decisions they worked with supplier partners to adjust stock levels and supply schedules. Some of the producer FMCG organisations said they had to consult their head offices about whether adequate stock was available in New Zealand before they could make decisions on what they were able to supply.

10.1.5 **Hospitality**

All the stand out indicators for the hospitality sector were to do with adaptation: leadership, minimisation of silos and decision making. At the time of writing (July 2012), some of these organisations were still closed as a result of the 22 February 2011 earthquake. The closed organisations were located in the CBD Red Zone prior to the earthquake. In interviews, owners and managers spoke of how they shepherded staff off organisational premises, mainly after the 22 February 2011 earthquake, and the close relationship they had with their staff before and after the earthquakes. From this account of leadership in the hospitality sector, it is unclear why there was a significant difference in leadership indicator scores between Surveys 1 and 2.

The other prominent indicators were decision making and minimisation of silos. Some hospitality organisations reported that they felt decisions to do with re-opening were dependent on many other factors they had no control over such as the cordon around the Red Zone, insurance payments and building renovations. Also, respondents reported that the size of the organisations and crossover of tasks in this industry acted to minimise silos. However, that this indicator had one of the larger score differences between Surveys 1 and 2 hints at a different scenario. It is also possible that the items did not apply to the respondent organisations.

10.1.6 **ICT**

Leadership was a prominent indicator for the ICT sector. Interviewed ICT organisations emphasised that leadership came not just from the people in leadership roles before the earthquakes but also from among other staff. Another prominent indicator was minimisation of silos. From interviews, one attribute of the ICT sector is the ability individuals have of working on their own for long periods of time on unique projects or in specialised areas. It was noted that this could lead to silos in organisations. After the earthquakes, there was a need for staff to work in groups on some new post-earthquake tasks or in close proximity for extended periods. Organisations reported that this was not always easy. On the other

hand, individuals being able to work on their own for long periods, to achieve organisational aims, is aided by devolved decision making and autonomy. Devolved decision making was the third indicator for ICT which had a significant difference between Surveys 1 and 2.

10.1.7 **Trucking**

Staff involvement was one of the indicators for the trucking sector that showed a larger difference between Surveys 1 and 2. Some of the trucking sector, mainly debris removal and construction, recognised the opportunity presented to them after the earthquakes. They also realised that the task was enormous and would require skilled manpower which was in short supply even before the earthquakes. However, some organisations spoke of their drivers leaving for other organisations that paid slightly better after the earthquakes. This was as the competition for demolition and debris removal contract work increased.

Leadership and internal resources were the other prominent indicators for trucking organisations. Apart from not having enough manpower, some truckers reported not having enough machinery and equipment (internal resources) for the work needed to be done after the earthquakes. Some of the machinery and equipment required was specific to work that was being done because of the earthquakes.

10.1.8 **Christchurch CBD**

Prominent indicators for Christchurch CBD were internal resources, leadership and decision making. Christchurch CBD organisations said it was difficult to make major decisions affecting their organisations immediately after the 22 February 2011 earthquake. This was because it was difficult to access organisational premises, records and stock that were in the CBD Red Zone. Lack of access to records meant that they could not access their customer databases or collect evidence for insurance. Apart from not accessing stock and hence not being able to trade, another of the CBD's biggest challenges was cash flow, which constitutes internal resources. In cases where organisations could not access premises for long periods of time, this meant that even if they could relocate, they may not have been able to afford new stock.

10.1.9 **Kaiapoi Town Centre**

In Kaiapoi the indicators showing a wider gap between Surveys 1 and 2 were to do with minimising silos, being innovative and creative as well as on internal resources and devolved

decision making. After the 22 February 2011 earthquake some of the respondents from Kaiapoi expressed that the community felt they had been abandoned as attention shifted to Christchurch. They equated this shift in attention to a shift in resources, by the authorities, as the problems in Christchurch were more visible. Respondents spoke of the need to work towards new and innovative ways of using the resources they had to get the town back on its feet again.

Respondents also spoke of the strong community spirit that existed before the earthquakes needing to be even stronger as they made plans to rebuild their town. However the drop in the minimisation of silos indicator score shows that they may not have been working so well together anymore. Lastly, they felt disempowered by some of the decisions made by the Recovery Authority (CERA) about issues such as land zoning, that they were no longer in control and were not consulted on their future. This may also have contributed to minimisation of silos coming to the fore.

10.1.10 Lyttelton Town Centre

The Lyttelton Town Centre organisations were the only group for whom situation monitoring and awareness was one of the indicators with a larger percentage difference between sampling times. The other two indicators were external resources and innovation and creativity. Organisations in Lyttelton also reported that they felt side lined by all the attention Christchurch had drawn. Further to this was the feeling that some recovery solutions proposed for Christchurch (e.g. moratoria on commercial expansion outside the CBD) would not be in the interests of Lyttelton and would divert resources to the Christchurch CBD. The respondents from Lyttelton reported that it was important for them to keep track of activities going on outside the town that might affect recovery.

Community based associations in Lyttelton were very active in leading recovery initiatives after the 22 February 2011 earthquake. The town acted faster in certain ways than Christchurch CBD, for instance in demolishing buildings. However, amidst all this activity, some organisations in the town felt that it was only a few people speaking louder than others and that not all opinions were being heard. This led to the feeling that it was not always majority ideas about the best innovative and creative ideas to implement in recovery.

10.2 Sectoral disaster resilience indicators - using information from impact data, contextual interviews and case studies

An alternative and additional way (to using the BRT) of arriving at the more important organisational disaster resilience indicators is to use the qualitative data provided by the disaster affected organisations. This includes information from contextual interviews, case studies and qualitative responses from the survey questionnaires (see section 6.5.4). One advantage of this is that these responses are a way in which the BRT can be continually improved by the addition of new information pertinent to disaster resilience. This is because respondents did not merely show a level of agreement with statements on business-as-usual organisational resilience. Instead, after experiencing disaster, they stated what relates to disaster resilience as they see it. Additionally, the BRT was developed during non-crisis times; questions used during business-as-usual may not be suitable after disaster.

From the contextual interviews and case studies, the most prominent indicators of organisational disaster resilience turned out to be ones to do with specific areas of organisational performance after the earthquakes. As described above, organisations depicted recovery as first returning to their pre-earthquake performance levels, exceeding those levels and the time taken to achieve this. Consequently, organisations reported that for them, the fundamental indicators of disaster resilience are those listed in Figure 10-1. They include evaluating post-earthquake revenue, staff and customer retention levels; the time taken to return to pre-earthquake levels of these components; as well as leadership and organisational adaptability.

Two case study respondents, one from the ICT sector and the other from the building suppliers sector emphasised that for them an additional mark of the organisation's disaster resilience was to what extent the organisation's safety procedures worked and were followed just after the earthquakes struck and with each major aftershock. Of all the case study organisations, these two placed a lot of emphasis on occupational health and safety. The ICT organisation is specialised in light manufacturing while the building supplier works with steel.

The indicators given in Figure 10-1 are in accord with findings from the organisational and disaster literature. For instance, Knight and Pretty (1996), in evaluating pre- and post-disaster organisational performance, demonstrate that effective crisis management can minimise

organisational losses. In other work Rose (2004) argues that resilience can also be measured in how long it takes to resolve a crisis.

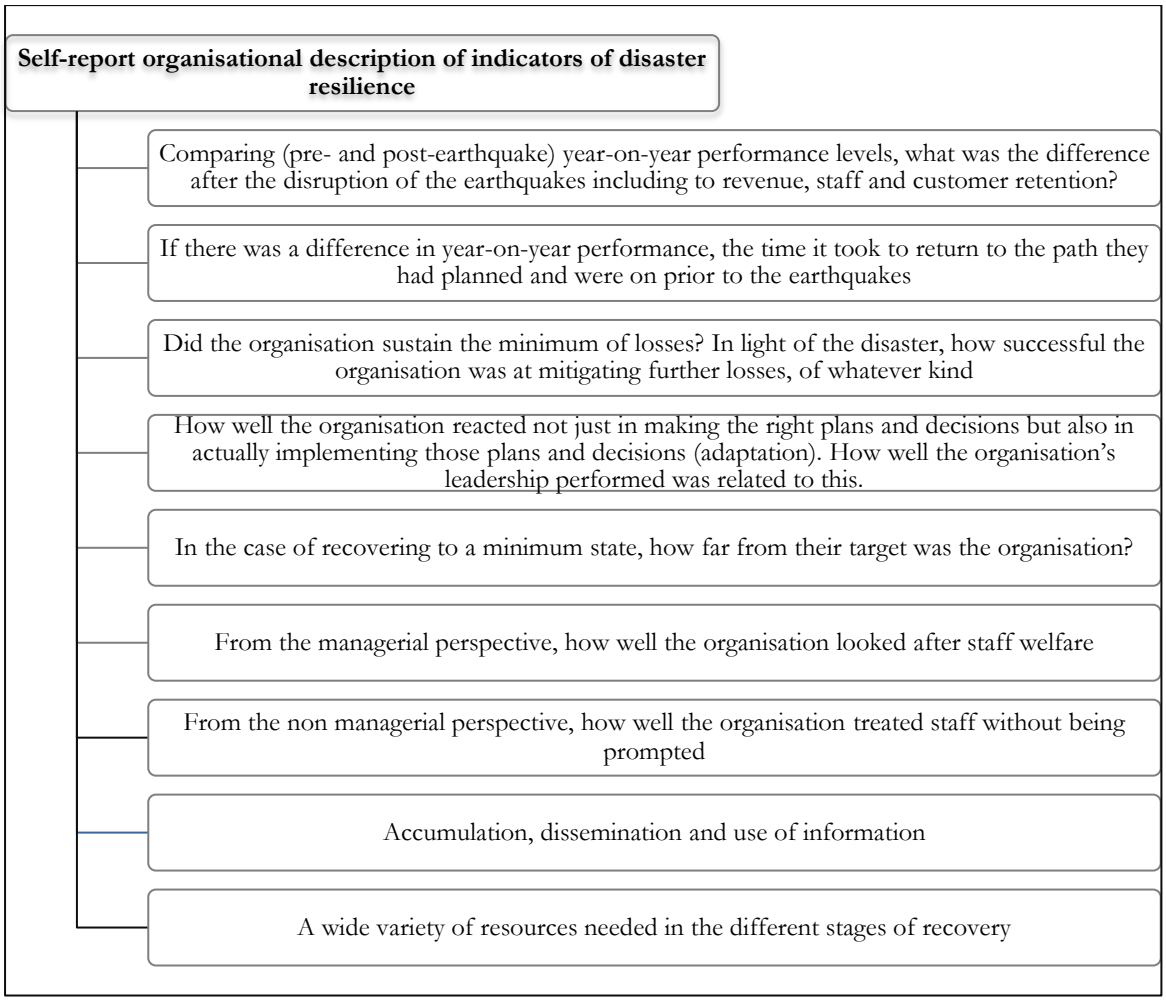


Figure 10-1: Self-report organisational description of measures of disaster resilience after the 2010-2011 earthquakes in Canterbury

For the organisations in Christchurch, when asked what their suitable measure of recovery was, organisations pointed to changes in revenue compared to pre-earthquake levels. As well, organisations indicated that the length of time, after the earthquakes, that it took for the organisation to return to pre-earthquake levels of revenue is also an indicator of the organisation's disaster resilience. Noticeably, these metrics are a mixture of traditional accounting and intangible measures and can be seen as subjective. Importantly, they translate into something organisations understand and can use for improvement. Neely et al (2002; 2005) contend that if performance metrics are to be acceptable and useful to organisations, they must be understandable to the organisation and measure aspects that are of value to the organisation.

10.3 Contrast of similar indicators of disaster resilience from quantitative data (using the Benchmark Resilience Tool - BRT) and from qualitative data (using interview responses)

Following its use after the Canterbury earthquakes, it is highlighted that the Benchmark Resilience Tool (BRT-53) in its present form does not adequately capture some of the aspects of organisational resilience that are present in or after disaster (more discussion on this later in this chapter). For instance, in interviews organisations provided their indicators of organisational disaster resilience. However, in the BRT-53, these indicators are not explicitly asked in the way described by organisations. Therefore, it is important to ascertain the differences between indicators of organisational disaster resilience provided by organisations and indicators currently contained in the BRT-53. Some of the distinctions from this analysis will be used in proposing modifications to the existing Benchmark Resilience Tool (BRT-53) for better capture of organisational disaster resilience attributes. The indicators proposed by organisations have been categorised into four main areas for the purposes of comparison. Also, for ease of comparison, the BRT-53 indicator naming convention (see appendix F) is used here and additional explanation of what the organisations meant is provided:

- → Staff (welfare/wellbeing and involvement);
- → Leadership (ability to delegate and devolved decision making);
- → Resources (more the availability and acquisition of resources from within and from without when they are needed and in the quantities required); and
- → Information and knowledge (however, not coupled as in the BRT).

Staff involvement: staff are an important component in organisational recovery after disaster. Fallara (2003) states that disaster recovery is a task that requires the assistance and co-operation of all staff in an organisation. In all interviews after the Canterbury earthquakes, respondents linked the employee's welfare to that of their family and community (more explanation on this is in chapter 6). Several interviewees spoke of employees' work performance being affected by the state of their family, friends and community. These are aspects not captured in the BRT.

Leaders' ability to delegate and devolved decision making: this arose from respondents realising that in disaster, decisions might have to be made in a hurry. Several respondents

spoke of indecision being a hindrance in response and recovery. Depending on what needed to be done, this meant that anyone in the organisation could find themselves having to make important decisions without conferring with management or other organisational hierarchy. This sometimes involved making decisions in areas traditionally not the employee's purview. Respondents felt that this kind of devolved decision making required the element of trust. Leaders needed to trust their staff to make decisions to the best of their ability under the circumstances and also staff needed to trust that there would be no adverse consequences afterwards. Turner (1976) and Smith (1990), in work on how organisational crises develop (see chapter 2), show that how a crisis is handled could lead to the escalation of that crisis.

Also related to decision making is the leaders' ability to delegate. This is an aspect not sufficiently accounted for in the BRT. Leaders' ability to delegate ensures that more is accomplished as the workload is carried by more than just a few people. After the Canterbury earthquakes, it also reinforced trust within the organisation and made people feel that they were part of the solution. Kay and Goldspink (2012) in their investigation on CEO views of organisational resilience found that trust was one of the central tenets in organisational resilience.

Organisations affected by the Canterbury earthquakes further related that apart from showing trust, delegation also meant that leaders acknowledged their limitations; that they did not know everything that was going on and had to rely on other people for some things to get done. Delegation also ensures there is less chance of individuals overworking which may make them increasingly inefficient in the long run. Another important aspect of leadership was knowing the right balance between autocracy and consultation in decision making in the response phase after the earthquakes.

It was often mentioned that some of those who emerged to lead after the earthquakes did not have leadership functional roles prior to the earthquakes. For both emergent leaders and those in traditional leadership roles, respondents spoke of the necessity of caring leaders as well as of inspired and inspiring leadership. Furthermore, it appears that those in leadership positions looked after the welfare of other members of staff but it was not clear who looked into their welfare. This is another facet that needs to be captured in the BRT.

Resources: in this research, this refers to two main sets of resources: those that the organisation would not necessarily require in business-as-usual, e.g. geotechnical engineering skills, and (sufficient) resources to maintain the organisation through vastly turbulent times.

These characteristics need to be considered in organisational disaster resilience and are not definitively incorporated in the BRT.

From responses in interviews, organisations need to be able to sustain extended periods of underperformance (if measured using revenue and sales) in the aftermath of disaster as the system moves to some kind of equilibrium. However, the organisation should still be able to rebound after this and start to be profitable again. An example from this study would be the building suppliers sector, many of whom reported revenue losses in the three consecutive periods they were asked about. This kind of prolonged revenue loss requires large resources to get through. Alesch et al (2009) showed how organisations can be affected in the long-term by disaster and that adequate resources are required to get through this period. However, Comfort et al (2004) caution that vast amount of resources are not the only factor in surviving disaster. They cite the need for coordination and communication also. These are aspects that have been discussed in this thesis, especially on the efficient and effective use of resources (see section 9.4.4).

Information and knowledge: according to respondents, in disaster situations having knowledge of how or what to do is not the same as having information. In addition, many people likened knowledge to the tacit kind. They thought of information as what had been distilled from all the *noise* that was present after the earthquakes and was useful to them. This is the reason for information and knowledge not needing to be coupled, as in the BRT, and should be accorded individual attention. Additionally, organisations reported that after the earthquakes, new roles and new tasks were defined; this required that the pre-earthquake channels of communication be modified. Especially tied to information were the notions of human and social capital. To get information, respondents said they had to know the right people to speak to. In many cases, networks formed prior to disaster were very useful. Respondents said it was not enough to form bonds between organisations; it was between the people in the different organisations that decisions were made. This is not explicit in the BRT.

10.4 Evolution of the Benchmark Resilience Tool (BRT-53)

The Benchmark Resilience Tool (BRT), like all tools that measure changing concepts, is a living tool that requires ongoing development. This is to keep up with evolving trends in organisations and in the environment around them and to make the information obtained

from the tool more useful to them. Using the BRT in disaster enabled the identification of some indicators necessary for organisational disaster resilience.

Apart from the differences in indicator description given in section 10.3, there are other aspects, picked up during the course of the research, that should be considered in the continual improvement of the BRT. Some of these aspects include the length of the BRT-53 and the phrasing of the items. Some respondents spoke of some of the questions in the BRT as not being suitable to their organisation or to the disaster situation. For example, it was difficult for smaller organisations to answer questions about organisational departments. In small- to medium-sized enterprises (SMEs), not all functions are separate processes. Other ways of improving the BRT as a survey instrument include reversing some of the items. Past studies on survey design show that reversing some of the items in a survey allows for more variance in responses (Alwin & Krosnick, 1991).

This section contains outcomes that are analysed and presented as part of this research's contribution to the betterment of the BRT. It should be emphasised that this study focuses on how the BRT can be improved mainly for the purposes of disaster resilience. Improvements to do with a version of the BRT for different sectors and for different size organisations as well as to do with reversing the items in the BRT are recommended as future work. This is because all the improvements discussed require thorough research and testing which is beyond the scope of this thesis. In summary, what should be included or thought of in the context of regional disasters for the BRT:

→ The extent of staff wellbeing. The employee, their family, their community;
→ Staff wellbeing, both of the leaders and the led;
→ Community wellbeing, which partly speaks to the BRT indicator *external resources* but also emphasises human and social capital;
→ Networking, to more explicitly include items on individuals within organisations being the link to cooperation and collaboration inside and outside the organisation and sector;
→ Location of organisations as pertains to hazards. This is with the awareness that organisations can be affected by other disasters that occur far from where they are;
→ In asking about preparedness and planning, that this is general enough to cover the broadest range of hazards but must not be agent (hazard) specific;

→ More consideration of the organisation's sector and the goods and services delivered, how they are delivered, where customers are located;

→ Pre-disaster situation of the sector or organisation (including community hazard planning and preparedness);

→ The extent of disaster. The organisation's level of resilience alone is not enough as this interacts with the higher level of disaster resilience which involves many other actors;

→ Size of the organisation. Some of the items in the tool are more suited to larger organisations. This raises the possibility of having different versions of the BRT in order to suit different size organisations. This can be extended to versions of the BRT-53 suited to different sectors. However, this might raise issues of cross comparing being difficult within and outside sectors;

→ Minimum level of resources for different stages in the response and recovery process;

→ The measures of excellence or performance require modification. For those organisations that are not-for-profits or government departments, a measure of recovery that is suitable for their organisation. A proposal of this thesis is that in addition to assigning a measure as is currently done in the BRT, organisations should be queried on how they measure doing well and that measure should subsequently be used to track their progress on either side of the time period in which they were queried. This helps to translate the message that one part of being resilient is for the organisation to do well whatever it is they do and that traditional measures of excellence might not after all suffice. It can be argued that an organisation's version or definition of resilience involves what they would like to achieve; there is no one-size-fits-all of organisational resilience. This also means that there is a relationship between the organisation's level of resilience and their management techniques. Further, combining organisational self-report performance indicators with those in the BRT asking about traditional indicators such as sales growth ensures that there is some compatibility in results from different organisations; and

→ Another version of the BRT for disaster situations or an *organisational disaster resilience module* to be added to the BRT, taking care that the questionnaire is not time expensive for respondents (see section 10.4.2 on length of the BRT questionnaire and some disadvantages when the full suite of items is deployed).

10.4.1 Proposed supplementary organisational disaster resilience module for the Benchmark Resilience Tool (BRT)

Bringing together several elements in this and in preceding chapters of this thesis: the quantitative information gleaned from the results of the BRT; the self-report disaster resilience indicators (section 10.2 and Figure 10-1) from the qualitative interviews with organisations; the signifiers of recovery (chapter 7); influential system behaviour (chapter 8); the critical success factors for sectoral recovery (chapter 9) and the possibility to continually improve the BRT; this section contains some possible items for inclusion in the BRT-53. These items are to help organisations identify possible areas of improvement for their disaster resilience. Some of the items are modified forms of existing items in the BRT-53. As with all survey research and design, the proposed items need to be tested before deployment as part of the BRT-53 or as a separate survey.

Organisations highlighted the importance of staff in the recovery of the organisation. These first three questions address the notion that a disaster would not be just one more reason for staff to leave the organisation:

- → What is your level of satisfaction at work?;
- → Please state possible reason(s) you may have for leaving this organisation;
- → Is there an issue at home, in your neighbourhood or in your community that affects your ability to do your job?;

Specific to small organisations:

- → What percentage of your personal wealth is invested in the organisation?;
- → Do you use personal resources for business purposes or vice versa?;

All other items:

- → The training provided by the organisation is relevant to the work I do;
- → Individuals in this organisation interact with others belonging to organisations we need to cooperate and collaborate with;
- → Our organisation engages with the community;
- → Our organisation works with the community in hazard preparation and planning;
- → Our organisation has identified what resources it can provide or contribute to staff in the case of a regional disaster;

→ Our organisation is aware of local hazards that would lead to disruption of operations;

→ Our organisation has prepared for these local hazards;

→ Our organisation has also prepared and planned for a broad range of hazards;

→ Our organisation's hazard plans are adaptable to different situations;

→ Our organisation regularly simulates disaster scenarios;

→ Our organisation has identified factors that may cause disruption to the supply and demand sides of the supply web;

→ Our organisation has identified the requirement, to consumers affected by a regional disaster, of our goods and services;

→ Our organisation would be able to obtain financial and other resources in the case of prolonged effects of a regional disaster affecting other organisations in the same area;

→ Our organisation knows that different resources and skills are required for different phases before and after a disaster;

→ Our organisation understands the minimum level of resources required for the different phases before and after a disaster;

→ What key performance indicators (KPIs) does your organisation use to monitor performance?; and

→ Using those key performance indicators (KPIs) how has your organisation performed in each of the last 5 years?

10.4.2 Benchmark Resilience Tool-53 (BRT-53) and Benchmark Resilience Tool-13 (BRT-13)

Other advancements to the BRT contributed by this research include the development and validation of a short-form of the BRT. The 13 indicators in the BRT combine to give an organisation's resilience score: the causal direction is from the indicators of organisational resilience to the latent construct of resilience. It is a latent construct because it cannot be measured directly but is instead measured using an aggregation of multiple items. The causal direction from the indicators to the latent construct suggests that the BRT-53 is a formative model (Jarvis, MacKenzie, & Podsakoff, 2003). Furthermore, original development of the BRT-53 involved grouping the items into indicators using measures of internal consistency and not on their unidimensional ability to measure resilience (see (Stephenson, 2010)).

Hinkin (1998) states that the reliability of a measure should be assessed after unidimensionality has been established. Unidimensionality as defined by Hattie (1985) is the existence of a single trait or construct underlying a set of measures. Unidimensionality for a scale ensures that all the items in the scale are measuring the same construct (in this case organisational resilience). Internal consistency is a measure of the strength of the correlation between different items. High measures of internal reliability are not sufficiently justified in the literature (Gerbing & Anderson, 1988) as a grouping mechanism when unidimensionality is not achieved. Furthermore, Boyle (1991) writes that a high measure of internal item consistency may also suggest a high level of item redundancy. In essence, this means that the same information is asked for in different items which need not be the case.

Consequently, using internal consistency to group the items may not be the most robust for a formative model such as the BRT. Reasons for this include that if the items are not unidimensional, it is unclear how the items affect each other. This is because the effects may be due to a different construct and not the one being measured. Additionally, grouping the items because they showed a high internal consistency may lead to low item variance, i.e. highly similar results across items which may be measuring different constructs. This is evidenced by the similarity in scores across sectors in each individual survey (see chapter 5). Lastly, these items contained in the BRT were not defined as unique factors, but were among many other items that showed high reliabilities as well. Using measures of internal consistency to group items means that some items which did not correlate highly were discarded and could be a required part in the formation of the latent construct of resilience. In a formative model such as the BRT, high correlations are not necessarily required between items. For example, while an organisation may have arrangements with other organisations for emergency supplies in the event of a crisis, it does not necessarily have to have arrangements with the community for assistance in recovering post-disaster. Both of these factors would contribute to that organisation's access to external resources; however, they do not necessarily have to be correlated.

The high internal consistency of the items in the BRT contributed to the development of a shorter version of the tool. The complete version of the BRT (called the BRT-53) contains 53 questions. When combined with questions investigating other phenomena, such as impacts of the earthquakes, requires a lot of time from respondents. This was the case when Survey 2 of this study was developed and deployed. As a result of the high internal consistency of the items and respondent survey fatigue or non-participation, a shorter

version of the BRT was developed, tested and validated. The shorter version of the tool is called the BRT-13 and has a single item representing each indicator (see (Z.R. Whitman et al., 2013)). It was found that the use of BRT-13 could accurately reproduce results when used in place of the full complement of questions contained in the BRT-53. A shorter questionnaire makes organisations more amenable to deploying it in their organisations and can only aid in further development of the concept of organisational resilience. This is one of the improvements to the BRT that this research has contributed.

10.4.3 **REAG and Resilient Organisations: BRT model comparison**

In other work, the developers of the BRT-53 (Resilient Organisations Research Programme - ResOrgs) collaborated with the Resilience Expert Advisory Group (REAG) of Australia. The REAG and ResOrgs originally had separate but similar sets of indicators. However, the REAG had a 3-factor model; leadership and culture, change ready and networks. Resilient Organisations on the other hand, had the 2-factor model made up of the planning and adaptive capacity.

REAG and Resilient Organisations worked together to align their indicators of resilience using a common language. The alignment resulted in the adoption of the REAG's 3-factor model and some modification to the items. This means that the Resilient Organisations indicators were re-arranged to fit the REAG model. The alignment resulted in the retention of the Resilient Organisation's 13 indicator model, grouped under the REAG's 3 factors. For the purposes of the BRT, while this collaboration resulted in some improvements to indicator names and item wording, as well as the addition of some new items to close identified gaps, the underlying structure of the BRT remained the same. Table 10-2 shows a comparison of the factor and organisational resilience scores using the 3-factor REAG and 2-factor Resilient Organisations models for results after Survey 1. The comparisons of the two models for Surveys 2 and 3 are contained in appendix F.

From the results in Table 10-2, there is no difference in the organisational resilience scores using either of the models. There is also very little difference in the scores for the individual factors and indicators. Part of the reason for this was discussed in sections 5.5 and 10.4.2 and has to do with the use of measures of internal consistency to group the items in the BRT. This way of grouping items in a formative scale may lead to low item variance and homogeneity of scores for different organisations.

Presently, the grouping of the indicators into different factors is useful for explanatory purposes as it is couched in language organisations can relate to. However, the primary focus for the continual development of the BRT should be the formation, validation, test and re-test of the items and indicators of resilience.

Table 10-2: Comparison of organisational resilience scores using REAG and Resilient Organisations models after Survey 1

Comparison of organisational resilience scores using REAG and Resilient Organisations models after Survey 1							
	REAG 3-Factor Model				**ResOrgs 2-Factor Model**		
	Leadership & Culture	**Change Ready**	**Networks**	**Average Sectoral Resilience**	**Average Sectoral Planning**	**Average Sectoral Adaptive Capacity**	**Average Sectoral Resilience**
Building Suppliers	64%	57%	58%	59%	54%	63%	59%
Critical Infrastructure	84%	84%	83%	84%	84%	84%	84%
FMCG	82%	70%	71%	75%	69%	80%	75%
Hospitality	70%	62%	65%	64%	59%	70%	64%
ICT	74%	59%	66%	65%	57%	73%	65%
Trucking	81%	69%	71%	72%	67%	78%	72%
Christchurch CBD	74%	65%	68%	68%	64%	73%	68%
Kaiapoi Town Centre	71%	61%	66%	65%	60%	70%	65%

10.5 Organisational disaster resilience and organisational recovery

All the organisations interviewed as part of this study mentioned the importance of an organisation being disaster resilient in relation to recovery. *Survive, bounce back, flexible* and *adaptable* were some of the words used to describe a resilient organisation. In chapter 2, recovery for organisations and sectors was defined as *when an organisation or sector can function and sustain itself (continually) in its new post-disaster environment.* It has since been established that the organisations and sectors in this study equated recovery to returning to pre-earthquake levels of performance or better (see chapters 4-7). However, is there a link between how organisations perform and their level of disaster resilience?

Organisations explained that one of their fundamental measures of recovery was change in revenue. From Survey 1 and Survey 2 deployed after the 4 September 2010 and 22 February 2011 earthquakes respectively, there was no significant statistical correlation found between the organisations' level of resilience (using BRT-53 scores) and their revenue (see chapter 7 for more detail).

Keeping in mind the time horizon (response and short-term recovery phases) for data collection, analysis of all the survey data shows that the organisation's BRT-53 resilience score was not a predictor of the direction of revenue change for organisations after the Canterbury earthquakes. For instance, using the case study information for a more detailed analysis, an organisation from Kaiapoi had a resilience score of 50% (out of a hundred) and showed a decrease in revenue in all three periods asked about in the study. On the other hand, a trucking organisation with a 33% resilience score exhibited revenue increases in all three periods. This again highlights that in the response and short-term recovery phase of a disaster, the indicators of resilience are different from those in peacetime. Correlations, at the sectoral level, between the recovery rate coefficient (RRC) and organisational resilience score, measured using the BRT-53, yielded no significant correlations except for the FMCG ($r=-.580$, $p<.05$) and trucking sectors ($r=-.692$, $p<.05$).

Consequently, it is worth investigating the link between an organisation's disaster resilience and its performance using some of the indicators described by the respondents (Figure 10-1). For this, it is important to recall that the fundamental definition of organisational resilience is that not only did the organisation get through the disaster or crisis, but that they eventually came out of it well. Authors such as Alpaslan and Mitroff (2004), Hamel and Valikangas (2003) as well as Seville et al (2008) agree with this view. The organisations in this study have shown a level of resilience by going through an acute phase in their existence and still carrying on. For instance, most of the case study organisations had RRC values of -2 after Survey 2. Nonetheless, none of them at the time of writing had ceased trading. However there are different levels to how the organisations performed after the earthquakes. Some of the organisations bounced back to where they were prior to the earthquakes, such as a lot of the ICT sector. Others managed to bounce forward even and are from different sectors: trucking, ICT and building suppliers.

10.5.1 Linking disaster resilience and recovery

The organisations in the study experienced a great deal of turbulence after the earthquakes but persevered and showed resilience[51]. Using the indicators of disaster resilience as given by organisations (section 6.5.4 and Figure 10-1), it can therefore be demonstrated that there is a link between an organisation's disaster resilience and its recovery after disaster. In addition, organisational disaster resilience has multiple aspects to it. What is also evident is that the measures for organisational disaster resilience should align with the short- to long-term strategy adopted by the organisation post-disaster. This is partly connected to the need for different resources and skills in the various stages after a disaster event. Organisational disaster resilience measures should also be in line with the extent of the disaster and some of the organisational pre-disaster conditions such as sector or economic conditions. This would make the measures more usable to organisations.

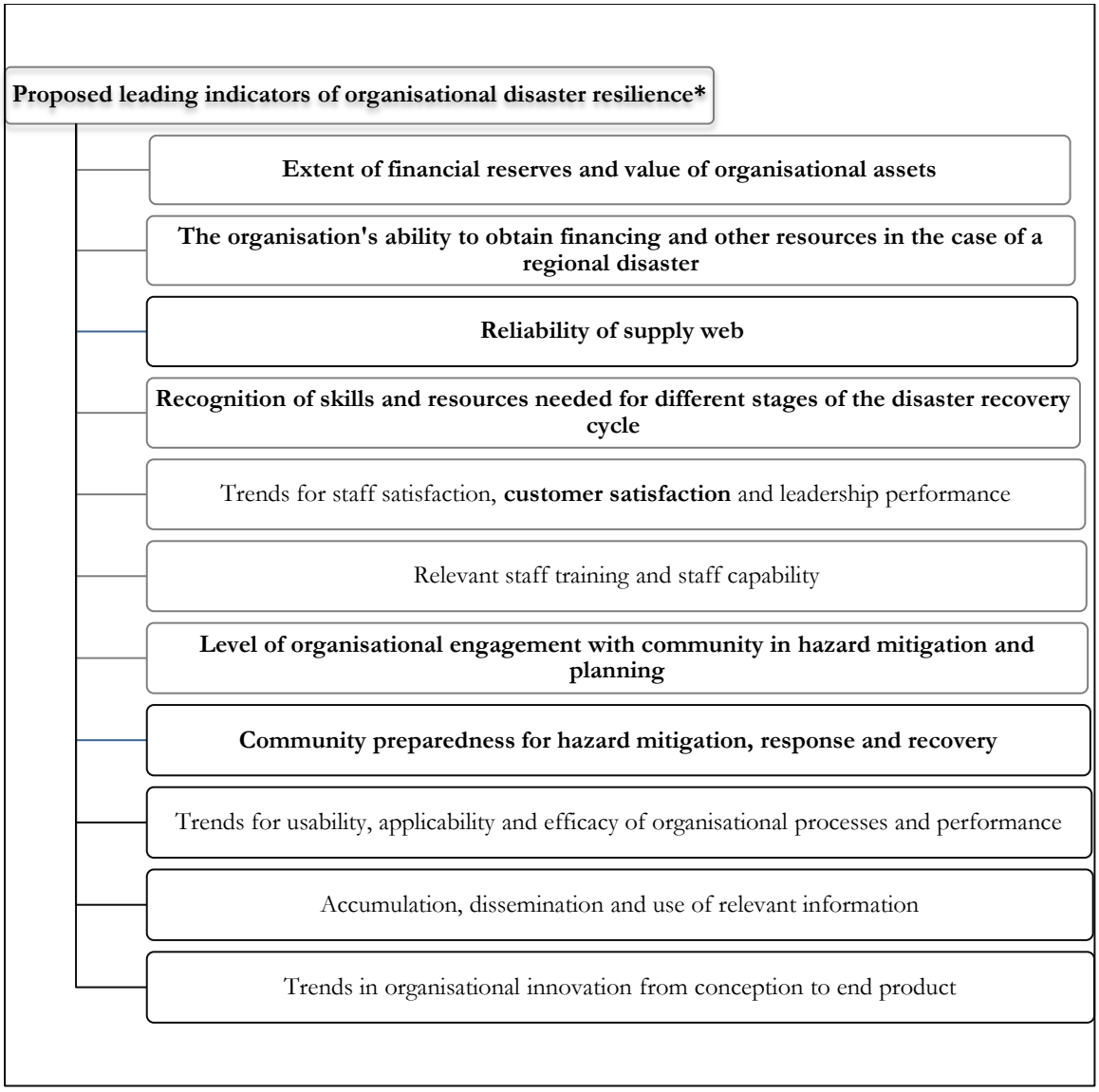
For instance, in asking about staff wellbeing after disaster, their situations away from work should also be asked about. It should be left to the employee to decide whether to give this information to their employer. Examples of the scale of a disaster are the localisation of damage after the 22 February 2011 earthquake and the quick restoration or non-disruption of service that enabled organisations that could to relocate to other areas of the greater Christchurch region. In addition, some of the sectoral pre-existing conditions played a part. For instance, some of the ICT industry was growing prior to the earthquake and some of the organisations report that their cash flow was good which acted as a buffer for much needed resources after the earthquakes. However, this buffer was not so large that it could sustain the organisations involved for extended periods of time. The organisations did not define what *extended* meant but it can be concluded that loss of revenue, unless by prior planning, is never good for the organisation.

Some organisations had alternate premises they found to work from after the earthquakes. Not all of them were planned for this purpose pre-earthquake, for instance, employees' homes. This showed quick thinking, ability for adaptation and was helped by the localisation of earthquake damage and availability of critical services. Other organisations consolidated branches, those branches affected by the earthquakes and those not so or not at all affected were merged. This shows an effective and efficient use of resources which become even more valuable after disaster and could allow the organisation a competitive edge.

[51] The hospitality organisation that was closed at the time of writing (July 2012) reported that they intended to re-open.

10.5.2 **Leading versus lagging indicators of organisational disaster resilience**

The indicators in Figure 10-1 were reported by organisations after their earthquake experiences: they are lagging indicators. Lagging indicators come after an event has occurred and are useful in confirming the occurrence of trends. The organisational self-report indicators of disaster resilience used in section 10.5.1 on the link between disaster resilience and recovery are lagging. Leading indicators on the other hand can be used to signal or predict future events. Therefore, there is a need for the identification of the leading indicators of disaster resilience if they are to be of use to organisations in future disaster situations. Using the lagging indicators of organisational resilience reported by the organisations, it is possible to determine leading indicators of organisational resilience for use in future. These are contained in Figure 10-2. In the figure, indicators in bold are new compared to those contained in the BRT-53 while those not in bold are similar to some in the BRT-53.



**Indicators in bold are new compared to those contained in the BRT-53 while those not in bold are similar to some in the BRT-53*

Figure 10-2: Proposed leading indicators of organisational disaster resilience identified from the organisational self-report lagging disaster resilience indicators

10.6 Sectoral disaster resilience

The definition of industry sector for this thesis is of a group of organisations that operate in the same segment of the economy or share a similar business type. Furthermore, according to Porter (2000), organisations from the same sector and in the same location form a cluster. Porter goes on to demonstrate that the health of the individual organisations is linked to that of the cluster. The organisations interviewed for this thesis reported that their performance and existence in Canterbury was tied to that of their sector. As industry sectors are the building blocks of the economy, this makes sectoral disaster resilience even more important.

Additionally, the different ways in which sectors were affected after the earthquakes in Canterbury demonstrates that industry sector is definitely one of the determinants of recovery after disaster. Level of effect is also dependent on the kind of disaster (e.g. earthquake, flood) and on other factors such as the economy. Consequently, some of the measures for organisational disaster resilience can be applied at the sector level. Alternately, it is possible to analyse the disaster resilience of a sector from the disaster resilience of the organisations within it.

For instance, the level of disruption to the sector after the earthquakes, how long before the sector got going after the earthquakes and the level of sectoral losses compared to pre-earthquake. After the Canterbury earthquakes, FMCG organisations were greatly disrupted but most managed to re-open within a few hours to a few days after the earthquakes. This enabled the minimisation of initial losses while still ensuring that customers were served. Similarly, the critical infrastructure organisations also mobilised themselves quickly to carry out repair and restoration.

Discussing disaster resilience at the sectoral level enables the organisations in the sector to have a common language on the subject. This could enable knowledge sharing and sectoral minimum disaster resilience standards. For example, organisations got together after the earthquakes to share best practise. This meant that resources were saved as not all organisations tried every alternative for themselves. It is not known how long into the recovery phase this cooperation will last. Regardless, in the event of another crisis of the same or different magnitude, these links already exist and organisations know who to call on.

Another aspect crucial in sectoral disaster resilience is that of collaboration within and between sectors. All the geographic sectors in the sample had groups of organisations that collaborated with each other to ensure that as many of them as possible got back on their feet. They reported that this was important because a certain level of competition was healthy and encouraged competitors to do better. They also added that choice was good for the customer. One Kaiapoi organisation reported that working with another organisation from Kaiapoi Town Centre enabled them to buy goods in bulk which they could not have been able to do on their own. In the trucking sector, such was the scale of the demand for their services that they worked together in some cases even pooling equipment. They also worked to share the workload. Two of the respondents say they recognised that the job was

extensive and that there was enough work for everyone. Intra- and inter-sectoral collaboration is a way of ensuring the recovery and survival of the sector post-disaster.

10.7 Chapter summary

Some of the collective wealth of the Canterbury region was depleted when buildings and other infrastructure were damaged in the 2010-2011 earthquakes. It will take massive resources, financial, physical, mental and human to replace this loss. Seemingly, some kind of economic benefit can develop from a disaster when individual businesses and sectors make new and sometimes better decisions while in the recovery phase. Some of these decisions include seismically retrofitting organisational premises, diversifying delivery of goods and services, adding to or improving existing product lines and identifying how they can better prepare for before and after a disaster. Consequently, this chapter demonstrates that the organisation's business-as-usual resilience is only one part of the larger resilience picture. Organisations also need to be disaster resilient.

This chapter proposes some ways of measuring organisational disaster resilience in addition to measuring business-as-usual resilience. While lagging indicators of disaster resilience, e.g. leadership performance and minimisation of staff, customer and financial losses, are useful for post-disaster analysis, in order to mitigate future crises and disasters, organisations require leading indicators of disaster resilience. Some of these leading indicators include:

- → the organisation's access to a wide and considerable range of resources for prolonged periods of adversity;
- → a reliable supply web;
- → pre-disaster engagement with other stakeholders such as the community and recovery authorities;
- → accumulation and utilisation of relevant information;
- → utility and demand of organisation's goods and services in disaster,
- → staff capability (at all levels); and
- → comprehension of the requirements in the different phases after disaster.

The extent of the Canterbury series of earthquakes was regional. It has been shown that resilience is context dependent and needs to be worked on constantly, especially in dynamic circumstances. This also means that organisations and sectors need to adopt an all hazards approach in assessing risk as no two disasters are alike.

The next, and final, chapter has the summary and conclusions of this research and some suggestions for future work.

11 Summary and conclusions

The Canterbury series of earthquakes re-affirms the notion that each disaster is unique and has its own set of recovery challenges. The 4 September 2010 and 22 February 2011 earthquakes in Canterbury are the manifestation of no two disasters being alike. This shows that the scale of a disaster should be a consideration in disaster planning, analysis and recovery. Additionally, as unique a phenomenon as the Canterbury earthquakes are, there are lessons that can be extracted and used by other organisations, sectors and policy planners that can help them plan for and deal with disaster. As stated earlier, the frame of reference for this thesis is from the bodies of work on organisations, crisis management and disaster recovery. This framework, underpinned by the use of system dynamics analysis and grounded theory, addresses gaps in the literature on:

- → some of the determinants of recovery, prosperity or failure for organisations and industry sectors after a major hazard event;
- → some of the aspects that are important in organisations in the immediate response and early recovery phase of disaster;
- → the key characteristics of disaster resilience for organisations and industry sectors as well as the interlinked nature of organisational and sectoral recovery; and
- → the development of a systems dynamics recovery framework for organisations and industry sectors.

The timeframe for this research was concentrated in the two phases following a disaster event: the response phase and the short-term recovery phase.

11.1 Research findings

In this thesis, it has been shown that different sectors are affected to varying degrees by the earthquakes. Even within the same sector, organisations are affected dissimilarly. Furthermore, as shown in chapter 7, there are three broad areas that contribute to organisational and sectoral vulnerabilities. These are: organisational level attributes, infrastructure used to deliver goods and services and external environmental factors. The environment being the context in which the organisation or the sector operates. Distinct combinations of these factors lead to differential

effects for organisations and sectors which in turn results in sectorally unique individual signifiers of recovery that have been identified in this work.

This means that in a disaster of a regional nature, the organisation's characteristics are only one part of how an organisation can be affected: organisational level attributes include the size of the organisation and its financial position. Environmental attributes, encompassing conditions and actions before, immediately after and in the short-term after disaster, all play a crucial role in understanding organisational and sectoral recovery. Some environmental attributes are the pre-disaster economic health of the affected region, the post-disaster demand for the organisation's goods and services and also interactions with other sectors or organisations.

Organisational location is another feature that can affect recovery; spatial analysis has shown the effects when organisations in built up areas such as Central Business Districts (CBDs) are affected by disaster and how this affects neighbouring organisations. Additionally, the infrastructure organisations rely on to distribute goods and services is susceptible to disaster, which in turn influences recovery. The infrastructure includes roads, information and communication technology as well as machinery.

Similarly, organisations and sectors follow different recovery trajectories dependent on the combination of the three broad areas of vulnerability identified. Elements that influence the recovery of sectors and organisations include leadership, staff, level of damage to assets, resource availability and post-disaster requirements for the organisation's goods and services. Other contributing elements are organisational size, diversity of product or market, type of goods and services delivered and favourable ecological conditions such as repaired infrastructure. Adaptability, availability of the right information as well as human and social capital have also been shown to be crucial in recovery. In Canterbury a Central Government employment subsidy was a major element in the recovery of organisations.

Conversely, there are factors that hinder recovery. Findings from this research point to the persistence and amplification of pre-disaster sectoral trends, e.g. skills shortage, which can affect recovery. After a regional disaster such as occurred in Canterbury, quick recovery of organisational and sectoral operations requires a large amount of resources, some of which the organisation does not have on hand. Specifically, finance for recovery may be difficult to obtain.

Other hindrances to recovery include delays in insurance payments, a shortage of skilled labour and equipment, as well as uncertain operating conditions. Uncertain conditions can be brought about by lack of information in general, or lack of relevant information in particular. Post-disaster, if there is a lack of information from credible sources such as experts and recovery agencies, information from other sources will fill the vacuum and this can be detrimental to recovery efforts. A logical use of information and communication is an aid in recovery. A further drawback in recovery is the mismatching of recovery needs and requirements, e.g. finance and manpower, and when these can be made available and delivered.

Preparedness and planning at the organisational level alone proved to not be enough in shielding organisations from the effects of disaster. After the earthquakes in Canterbury, organisational pre-disaster preparedness did not turn out to be the most important factor in recovery. However, for some sectors, the existence of prior plans was helpful to a limited extent, especially practised plans. It emerged that prior practising of emergency plans is helpful in so far as defining actions that may be required in the response phase after a disaster. However, even for organisations with documented and practised emergency plans, decisions made by agents in the organisational system's environment also added to disaster effects. For instance, community or local authority decisions on seismic retrofitting of unreinforced masonry buildings in the CBD and town centres.

After the Canterbury earthquakes, there was also evidence of temporal effects occurring in the different phases after a disaster event. Effects in the response phase are not the same as in the short-term recovery phase. The different phases require different ways of thinking, different skillsets and different resources. An understanding of this is of assistance in the allocation of organisational or sectoral resources for recovery. Specifically from the systems point of view, there are a lot of reinforcing feedback loops between sectors in the response phase which is characterised by immense uncertainty. In the short-term recovery phase, some of the reinforcing feedback loops are broken as organisations and sectors adjust and make recovery decisions based on the information at hand.

Another finding in this work is that there are multiple stakeholders in recovery (see chapters 6 and 9). For Canterbury, stakeholders whose actions affect each other include the Recovery Authority, the social community, the business community and local authorities. The post-

disaster recovery of organisations and sectors depends on the individual choices they make and also on decisions made by the communities they are part of. Crucially, the Recovery Authority can influence but cannot determine whether organisations and sectors recover. In such a system, the perception that organisations, sectors and the community have of clear recovery leadership is essential. As such, the Recovery Authority can help to create conditions conducive to aiding organisational and sectoral recovery. One way of achieving this is through the issuing of a clear statement of the transition from response to short-term recovery to help define the recovery actions taken by organisations and sectors. Furthermore, there are points of intervention at which recovery can be effected. The use of policy to achieve recovery aims has been identified as one way to leverage specific points in the system to aid in recovery. Other points of leverage, such as clear communication between stakeholders, should also be used to improve and optimise the functioning of the system.

Finally, this thesis also adds to the body of knowledge on disaster resilience. Organisational disaster resilience is a growing field and our incremental understanding of it and its crucial aspects is important. It has been shown that business-as-usual organisational resilience and organisational disaster resilience are interconnected parts of the overall resilience frame. Organisational disaster resilience involves many more agents and is associated with the scale or extent of a disaster.

This thesis has furthered the discussion on possible metrics that organisations and sectors can use in the development of indicators of disaster resilience. The measures of disaster resilience provided by respondents from disaster affected organisations in this study are one part of this subject area. Some of these measures are staff wellbeing which is linked to family and community wellbeing, leadership ability to delegate to achieve organisational recovery aims, organisational adeptness at working with external agents, availability and access to a wide range of resources as well as the use of information and communication in ways that are beneficial to organisational recovery.

11.2 Research recommendations

Demonstrably, aggregated reporting of the effects of disaster, at national or regional levels, may conceal the effects to individual sectors and make it difficult to formulate effective recovery

programmes. As such, the effects of disaster should be reported for individual sectors and recovery plans should consider the differential effects. Additionally, from the breadth of agents listed as influencing recovery, it is advantageous for organisations and sectors to adopt systemic thinking to assess how they would be affected by a broad range of hazards. Understanding and working with the structure of a system can be used to influence the behaviour of the system.

In recovery for organisations and sectors, adequate support for staff is necessary as they are a vital part of recovery efforts. This is for both before and after a disaster event. Support for staff can also be through work with the community that organisations exist in. Furthermore, after the experience of the multiple earthquakes in Canterbury, organisations should review the insurance of their assets, understand the provisions of their insurance policy and ensure appropriate cover.

Organisations, sectors and recovery authorities should aim to reduce or eliminate uncertainty in order to aid recovery. There should be an effort made to identify needs and requirements and the timely provision and delivery of these. Similarly, finance is important for recovery. It is crucial to create conditions that keep money flowing in the economy. Additionally, prior recognition of what resources will be needed in response and recovery after disaster should be identified before the eventuation of a disaster.

Recovery from disaster cannot and should not be separated from disaster preparedness and mitigation. In addition to the existence of documented emergency and business continuity plans, enactment of these plans is essential. As part of recovery, organisations should aim to objectively analyse their actions in response and recovery and incorporate these into future preparedness and planning activities. It is important that these activities are incorporated into plans that are general enough to be applied in multiple hazards situations. The incorporation of systems thinking is necessary in all hazard planning, preparation and mitigation activities.

It is of value for organisations and sectors to recognise that the time periods after disaster, i.e. response and short-term recovery, are different and require different ways of thinking, skillsets and resources. Existing organisational analysis methods can be employed to help with the identification of an organisation's more important elements in recovery. This is one way to make use of the wealth of knowledge in the wider organisational literature for post-disaster recovery. Again, these traditional organisational analysis tools should be used in combination with systems

thinking. Systems thinking and analysis should also be used to recognise potential feedback loops to counteract the reinforcing feedback loops present in the response phase characterised by uncertainty.

Another recommendation in this work is that the stakeholders in the recovery effort should be identified and engaged early in the process. From the experience in Canterbury, the setup and reporting structure of the Recovery Authority also needs to be considered as this may affect engagement with other stakeholders. It is important that the Recovery Authority works with other stakeholders in cooperation to maximise recovery efforts. Successful recovery requires that stakeholders work towards similar goals. Therefore, articulating clearly the overall recovery goal(s) for all stakeholders to align with can be of benefit. For the actual recovery process, the order of planning and execution of the recovery strategy is equally vital. This should incorporate the balance between measures in the response phase with those in the short-term recovery phase. It is important to note that many of the decisions made and actions carried out in recovery can be highly contested at the time. This, however, should not stop the crafting of a recovery plan with involvement of stakeholders.

In addition, post-disaster recovery policy should be formulated and targeted at specific problems while also considering the long-term and wider implications. Policy should also be enacted with the overall goal in mind. As well, in the New Zealand context, the Recovery Manager's role as defined by the Ministry of Civil Defence and Emergency Management (MCDEM) should be effectively utilised during the response phase. This would allow for an assessment of short-, medium and long-term impacts of decisions made during this initial phase after a disaster. This may help when making the transition from response to recovery as well as in balancing response and recovery plans.

While preparedness and business continuity plans may contribute to organisational and sectoral survival in the short-term after disaster, there is as yet no rehearsed plan for long-term recovery before an event has occurred. Consequently, disaster resilience is key. The monitoring and measuring of organisational and sectoral disaster resilience cannot be overemphasised. However, any such metrics should be understandable and usable by organisations and sectors and aid in decision making.

11.3 Future work

The findings in this thesis are only the start of the documentation into how different industry sectors are affected by disaster. Future research is needed to identify what other actions organisations can engage in to prevent or mitigate the effects of disaster. The concept of viewing organisations and sectors as self-organising systems within the context of larger systems provides a foundation for further elaboration, discussion and development. The next steps:

11.3.1 Continual improvement of the Benchmark Resilience Tool BRT-53

The BRT-53, like any other tool, requires continuous improvement. Some of the possible enhancements include reversing some of the questions in BRT-53 to achieve better variance among respondents; develop different versions of the BRT-53 for organisations with different characteristics such as sector, size as well as for-profits and not-for-profits; and also develop a BRT-53 version or a module within the BRT-53 specifically for organisational disaster resilience. Another research strand involving the BRT-53 is the detailed explanation for all the sectoral indicator scores after disaster as each organisation and sector may have distinct explanations for how the indicators relate to them.

11.3.2 Survivor bias

One aspect of this research is that the organisations followed are those that could be contacted during the course of the study. Consequently, there is a possibility of survivor bias. An area to be explored further is to track organisations that reported permanent closure or those that intended to re-open at the time of writing (October 2012). Therefore, future research should incorporate investigation of organisational and sectoral recovery trajectories at longer times from the occurrence of the disaster event and using multiple indicators (financial and non-financial) of organisational recovery.

Apart from tracking organisations that closed, the progress of the recovery process (four, eight and 10 years from the 4 September 2010 earthquakes) for all the organisations involved in the study is also important. This can also enable investigation, in the long-term, of how factors such as the global financial crisis may have had an effect on sectoral medium- to longer-term recovery.

11.3.3 Comparison of recovery processes for different disasters

Comparing the recovery process in Christchurch to that after other disasters enables the learning of what worked in different contexts and how this affected organisational and sectoral recovery. The findings can be used to deduce if there are any similarities across disasters and if these similarities can be used to contribute to the development of pre-disaster indicators.

11.3.4 Investigate the interaction of employee, community and organisational disaster resilience

In this thesis, a crucial finding is that the recovery of organisations and sectors is dependent on the recovery of staff. However, staff recovery is closely linked to the wellbeing of their families and communities. The investigation of the interaction between employee, community and organisational disaster recovery and resilience is one area that merits further attention.

11.3.5 Quantification of the system dynamics models

Lastly, an area requiring further enquiry is the completion and detailed analysis of the quantified system dynamics diagrams. Quantification of system dynamics models can also help to determine the effects to the system when certain parameters are modified. The quantified models can then be used to determine future recovery trajectories which can be compared with real world scenarios. The results from the quantification and analysis can also be used as input in policy formulation and disaster recovery planning.

12 References

Ackoff, R.L. (1981). The Art and Science of Mess Management. *Interfaces*, 20-26.

Ackoff, R.L. (2004). *Transforming the Systems Movement.*

Aldrich, D.P. (2008). The Crucial Role of Civil Society in Disaster Recovery and Japan's Preparedness for Emergencies. *Japan aktuell, 3*, 81-96.

Aldrich, H.E., & Pfeffer, J. (1976). Environments of organizations. *Annual review of sociology, 2*, 79-105.

Alesch, D.J., Arendt, L.A., & Holly, J.N. (2009). *Managing for long-term community recovery in the aftermath of disaster*: Public Entity Risk Institute.

Alesch, D.J., & Holly, J.N. (1996). *How to survive the next natural disaster: Lessons for small business from Northridge victims and survivors.*

Alesch, D.J., & Holly, J.N. (1998). *Small business failure, survival, and recovery: lessons from the January 1994 Northridge Earthquake.* Paper presented at the Paper presented at the NEHRP Conference and Workshop on Research on the Northridge, California Earthquake of January 17, 1994.

Alesch, D.J., & Holly, J.N. (2002). *Robustness and Resiliency, Ruin and Recovery.*

Alesch, D.J., Holly, J.N., Mittler, E., & Nagy, R. (2001). *Organizations at risk: What happens when small businesses and not-for-profits encounter natural disasters*: Public Entity Risk Institute PERI.

Alexander, D.E. (1981). Disaster in Southern Italy: November 1980. *Geographical Magazine, 53*(9), 553-561.

Allen, R., & Toder, F. (2004). A model of organizational recovery. *Journal of Emergency Management, 2*(1), 41.

Alpaslan, M.C., & Mitroff, I.I. (2004). Bounded Morality: The Relationship Between Ethical Orientation and Crisis Management, Before and After 9/11. *Current Topics in Management, 6*, 13-43.

Alwin, D.F., & Krosnick, J.A. (1991). The reliability of survey attitude measurement. *Sociological Methods & Research, 20*(1), 139-181.

Anderson, W.A. (1969). Disaster and Organizational Change. a Study of the Long-term Consequences in Anchorage of the 1964 Alaska Earthquake: DTIC Document.

AS/NZS ISO 31000:2009. Risk management – Principles and guidelines.

Asbjornslett, B.E. (1999). Assess the vulnerability of your production system. *Production Planning & Control, 10*(3), 219-229.

Asuero, A.G., Sayago, A., & Gonzalez, A.G. (2006). The correlation coefficient: An overview. *Critical reviews in analytical chemistry, 36*(1), 41-59.

Australian Bureau of Statistics (Producer). (2012, 9 July 2012). Business Longitudinal Survey (BLS). Retrieved from http://www.abs.gov.au/websitedbs/D3310114.nsf/home/home?opendocument#from-banner=GT

Avery, R.B., Bostic, R.W., & Samolyk, K.A. (1998). The role of personal wealth in small business finance. *Journal of Banking & Finance, 22*(6-8), 1019-1061.

Bak, P., Tang, C., & Wiesenfeld, K. (1988). Self-organized criticality. *Physical review A, 38*(1), 364-374.

Barksdale, D. (1998). Disaster recovery response to Tropical Storm Alberto. *Disaster Management Programs for Historic Sites, San Francisco and Albury: Association for Preservation Technology (Western Chapter) and The Johnstone Centre, Charles Sturt University*, 133-138.

Bateson, G. (1972). *Steps to an Ecology of Mind*: University of Chicago Press.
Beavan, J., Fielding, E., Motagh, M., Samsonov, S., & Donnelly, N. (2011). Fault location and slip distribution of the 22 February 2011 MW 6.2 Christchurch, New Zealand, earthquake from geodetic data. *Seismological Research Letters, 82*(6), 789-799.
Beaver, W.H., & Demski, J.S. (1974). The nature of financial accounting objectives: A summary and synthesis. *Journal of Accounting Research*, 170-187.
Beer, S. (1989). Viable system model. *Viable Systems Model, Wiley, Chicester*.
Belegundu, A.D., & Chandrupatla, T.R. (1999). *Optimization concepts and applications in engineering*: Prentice Hall Upper Saddle River, NJ.
Bell, M.A. (2002). The Five Principles of Organizational Resilience. *Gartner Research.[Online]*.
Bengtsson, M., & Kock, S. (2000). *Coopetition* in Business Networks - to Cooperate and Compete Simultaneously. *Industrial marketing management, 29*(5), 411-426.
Berger, A., & Udell, G. (1998). The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle.
Berke, P.R., Kartez, J., & Wenger, D. (1993). Recovery after disaster: achieving sustainable development, mitigation and equity. *Disasters, 17*(2), 93-109.
Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural Hazards, 41*(2), 283-295.
Bhamidipati, K. (Producer). (2010, 31 December 2010). Would You Build a House Without a Blueprint? Managing the Requirements and Design Phases of Your Application Projects. Retrieved from http://sapinsider.wispubs.com/Article/Would-You-Build-a-House-Without-a-Blueprint--Managing-the-Requirements-and-Design-Phases-of-Your-Application-Projects/5458
Birkland, T.A., Herabat, N.Y.P., Little, R.G., & Wallace, W. (2005). *Impact of the Boxing Day Tsunami on Tourism in Thailand*.
Blaikie, P.M. (1994). *At risk: natural hazards, people's vulnerability, and disasters*: Psychology Press.
Boisot, M., & Child, J. (1999). Organizations as adaptive systems in complex environments: The case of China. *Organization Science, 10*(3), 237-252.
Bolin, R.C. (1994). *Household and community recovery after earthquakes*: Institute of Behavioral Science, University of Colorado Boulder, CO.
Bolin, R.C., & Stanford, L. (1991). Shelter, housing and recovery: A comparison of US disasters. *Disasters, 15*(1), 24-34.
Bolin, R.C., & Stanford, L. (1998). *The Northridge earthquake: Vulnerability and disaster*: Routledge.
Borgatti, S. (2004). Introduction to grounded theory, Analytic technologies.
Box, G.E.P., & Draper, N.R. (1987). *Empirical model-building and response surfaces*: John Wiley & Sons.
Boyle, G.J. (1991). Does item homogeneity indicate internal consistency or item redundancy in psychometric scales? *Personality and individual differences, 12*(3), 291-294.
Bradley, B.A. (2012). Ground Motion and Seismicity Aspects of the 4 September 2010 Darfield and 22 February 2011 Christchurch Earthquakes.
Brewer, N.T., Weinstein, N.D., Cuite, C.L., & Herrington, J.E. (2004). Risk perceptions and their relation to risk behavior. *Annals of Behavioral Medicine, 27*(2), 125-130.
Bruneau, M., Chang, S.E., Eguchi, R.T., Lee, G.C., O'Rourke, T.D., Reinhorn, A.M., . . . von Winterfeldt, D. (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. *Earthquake Spectra, 19*, 733.

Bruns, W. (1998). *Profit as a performance measure: powerful concept, insufficient measure.* Paper presented at the Theory and Practice: the First International Conference on Performance Measurement, Cambridge.

Buchanan, B. (Producer). (2011, 9th June 2012). Christchurch earthquake redraws retail property map. [Article] Retrieved from http://www.tower.co.nz/investments/news/property/2011/christchurch-earthquake-redraws-retail-property-map

Bunge, M. (1985). *Treatise on Basic Philosophy: Epistemology and Methodology III: Philosophy of Science and Technology, Pt I-Formal and Physical Sciences* (Vol. 7): Reidel.

Campbell, DT, & Fiske, DW. (1998). Convergent and discriminant validation by the multitrait-multimethods matrix. *Personality, 56*, 162.

Canis, B. (2011). The Motor Vehicle Supply Chain: Effects of the Japanese Earthquake and Tsunami. *Congressional Research Service*.

Cannon, M.D., & Edmondson, A.C. (2005). Failing to Learn and Learning to Fail (Intelligently): How Great Organizations Put Failure to Work to Innovate and Improve. *Long range planning, 38*(3), 299-319.

Canterbury Economic Development Co. Ltd. (2009). Canterbury Regional Economic Development Strategy (CREDS) 2005 – 2015. Christchurch.

Canterbury Engineering Lifelines Group. (1997). Risks and Realities: A Multidisciplinary Approach to the Vulnerability of Lifelines to Natural Hazards

Canterbury Engineering Lifelines Group (2011). [Costs Saved After Seismic Reinforcement of Major Assets].

Careers New Zealand. (2011a). Residential building sector struggles in 2011.

Careers New Zealand. (2011b). Recession affects demand for staff in some areas of hospitality.

Carpenter, S.R., Walker, B., Anderies, J.M., & Abel, N. (2001). From metaphor to measurement: resilience of what to what? *Ecosystems, 4*(8), 765-781.

Carroll, A.B. (1991). The pyramid of corporate social responsibility: toward the moral management of organizational stakeholders. *Business horizons, 34*(4), 39-48.

Carroll, J.S., & Fahlbruch, B. The gift of failure: New approaches to analyzing and learning from events and near-misses.î Honoring the contributions of Bernhard Wilpert. *Safety Science, 49*(1), 1-4.

Central City Business Association (Producer). (2011, 9 July 2012). Christchurch Central City. Retrieved from http://www.christchurchcity.org.nz/index.php

Chakravarthy, B.S. (1986). Measuring strategic performance. *Strategic Management Journal, 7*(5), 437-458.

Chamlee-Wright, E., & Storr, V. (2008). The Entrepreneur's Role in Post-Disaster Community Recovery: Implications for Post-Disaster Recovery Policy. *Mercatus Policy Series*.

Chang-Richards, A.Y., Seville, E.P., Wilkinson, S., & Brunsdon, D. (2012). Resourcing Issues in Past Disaster Recoveries: Some Perspectives.

Chang, S.E. (1983). Disasters and Fiscal Policy: Hurricane Impact on Municipal Revenue. *Urban Affairs Review, 18*(4), 511-523.

Chang, S.E. (2010). Urban disaster recovery: a measurement framework and its application to the 1995 Kobe earthquake. *Disasters, 34*(2), 303-327.

Chang, S.E., & Falit-Baiamonte, A. (2002). Disaster vulnerability of businesses in the 2001 Nisqually earthquake. *Global Environmental Change Part B: Environmental Hazards, 4*(2), 59-71.

Chang, S.E., & Miles, S.B. (2004). 10 The Dynamics of Recovery: A Framework. *Modeling spatial and economic impacts of disasters*, 181.

Chang, S.E., & Nojima, N. (2001). Measuring post-disaster transportation system performance: the 1995 Kobe earthquake in comparative perspective. *Transportation research part A: policy and practice, 35*(6), 475-494.
Chang, S.E., Rose, A., Shinozuka, M., Svekla, W.D., & Tierney, K.J. (2000). *Modeling earthquake impact on urban lifeline systems: advances and integration*.
Chang, S.E., & Shinozuka, M. (2004). Measuring improvements in the disaster resilience of communities. *Earthquake Spectra, 20*(3), 739-755.
Chang, S.E., Svekla, W.D., & Shinozuka, M. (2002). Linking infrastructure and urban economy: simulation of water-disruption impacts in earthquakes. *Environment and Planning B, 29*(2), 281-302.
Charmaz, K. (2003). Qualitative interviewing and grounded theory analysis. *Inside interviewing: New lenses, new concerns*, 311-330.
Checkland, P.B., & Haynes, M.G. (1994). Varieties of systems thinking: the case of soft systems methodology. *System Dynamics Review, 10*(2 - 3), 189-197.
Choi, TY, Dooley, KJ, & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: control versus emergence. *Journal of Operations Management, 19*(3), 351-366.
Christopher, M. (2000). The Agile Supply Chain: Competing in Volatile Markets. *Industrial marketing management, 29*(1), 37-44.
Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management, The, 15*(2), 1-14.
Christopher, M., & Rutherford, C. (2004). Creating supply chain resilience through agile six sigma. *Critical Eye*, 24ñ28.
Churchman, C.W. (1979). *The systems approach and its enemies*: Basic Books New York.
Clarke, L.B. (1991). *Acceptable risk?: Making decisions in a toxic environment*: Univ of California Press.
Clarke, L.B. (2001). *Mission improbable: Using fantasy documents to tame disaster*: University of Chicago Press.
Coburn, A.W., Spence, R.J., & Pomonis, A. (1991). Vulnerability and risk assessment. *UNDP/UNDRO Training Module*.
Collins, J. (2001). Good to Great. Retrieved 13 January 2011, 2011, from http://www.jimcollins.com/article_topics/articles/good-to-great.html
Comerio, M.C. (1997). Housing issues after disasters. *Journal of Contingencies and crisis management, 5*(3), 166-178.
Comerio, M.C. (2011). Observations from Mary Comerio.
Comfort, L.K. (1999). *Shared risk: Complex systems in seismic response*: Pergamon.
Comfort, L.K. (2005). Risk, security, and disaster management. *Political Science, 8*.
Comfort, L.K., Ko, K., & Zagorecki, A. (2004). Coordination in rapidly evolving disaster response systems. *American Behavioral Scientist, 48*(3), 295.
Comfort, L.K., Sungu, Y., Johnson, D., & Dunn, M. (2001). Complex systems in crisis: anticipation and resilience in dynamic environments. *Journal of Contingencies and crisis management, 9*(3), 144-158.
Comfort, L.K., Wisner, B., Cutter, S., Pulwarty, R., Hewitt, K., Oliver-Smith, A., . . . Krimgold, F. (1999a). Reframing disaster policy: the global evolution of vulnerable communities. *Environmental Hazards, 1*(1), 39-44.
Comfort, L.K., Wisner, B., Cutter, S.L., Pulwarty, R., Hewitt, K., Oliver-Smith, A., . . . Krimgold, F. (1999b). Reframing disaster policy: the global evolution of vulnerable communities. *Environmental Hazards, 1*(1), 39-44.

Cook, R. (1998). How complex systems fail. *Cognitive Technologies Laboratory, University of Chicago. Chicago IL*.

Coopers & Lybrand. (1997). Liability and Insurance - Infrastructure and Assurance: President's Commission on Critical Infrastructure Protection (PCCIP).

Corey, C.M., & Deitch, E.A. (2011). Factors affecting business recovery immediately after Hurricane Katrina. *Journal of Contingencies and crisis management, 19*(3), 169-181.

Cornell, J.A., & Berger, R.D. (1987). Factors that influence the value of the coefficient of determination in simple linear and nonlinear regression models. *Phytopathology, 77*(1), 63.

Couto, R.A. (1989). Economics, Experts, and Risk: Lessons from the Catastrophe at Aberfan. *Political Psychology, 10*(2), 309-324.

Coyle, R.G. (1977). *Management System Dynamics* (Vol. 6): Wiley New York.

Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J., & Handfield, R.B. (2007). The severity of supply chain disruptions: design characteristics and mitigation capabilities. *Decision Sciences, 38*(1), 131-156.

Cruz, A.M., & Steinberg, L.J. (2005). Industry preparedness for earthquakes and earthquake-triggered hazmat accidents in the 1999 Kocaeli earthquake. *Earthquake Spectra, 21*, 285.

Cutcliffe, J.R. (2000). Methodological issues in grounded theory. *Journal of advanced nursing, 31*(6), 1476-1484.

Daellenbach, H.G. (1994). *Systems and decision making: a management science approach*: Wiley New York.

Dahlhamer, J.M., & Reshaur, L. (1996). Businesses and the 1994 Northridge earthquake: An analysis of pre-and post-disaster preparedness.

Dahlhamer, J.M., & Tierney, K.J. (1996). Winners and losers: predicting business disaster recovery outcomes following the Northridge earthquake.

Dahlhamer, J.M., & Tierney, K.J. (1998). Rebounding from disruptive events: Business recovery following the Northridge earthquake. *Sociological Spectrum, 18*(2), 121-141.

Dantas, A., Seville, E.P., & Nicholson, A. (2006). Information sharing during disaster: Can we do better?

Davenport, T.H., & Stoddard, D.B. (1994). Reengineering: business change of mythic proportions? *MIS quarterly*, 121-127.

Dawson, S. (1992). *Analysing Organisations*: Macmillan.

Denzin, N. (2009). *The research act: A theoretical introduction to sociological methods*: Aldine De Gruyter.

Dervitsiotis, K.N. (2003). The pursuit of sustainable business excellence: Guiding transformation for effective organizational change. *Total Quality Management & Business Excellence, 14*(3), 251-267.

Dervitsiotis, K.N. (2004). Navigating in Turbulent Environmental Conditions for Sustainable Business Excellence. *Total Quality Management & Business Excellence, 15*(5), 807-827.

Dietch, E.A., & Corey, C.M. (2011). Predicting long-term business recovery four years after Hurricane Katrina. *Management Research Review, 34*(3), 311-324.

Dietz, T., Dolsak, N., Ostrom, E., & Stern, P.C. (2002). The drama of the commons. *The drama of the commons*, 3ñ35.

Diggle, P. (2002). *Analysis of longitudinal data* (Vol. 25): Oxford University Press, USA.

Dodge, H.R., Fullerton, S., & Robbins, J.E. (1994). Stage of the organizational life cycle and competition as mediators of problem perception for small businesses. *Strategic Management Journal, 15*(2), 121-134.

Dooley, K.J. (1997). A complex adaptive systems model of organization change. *Nonlinear Dynamics, Psychology, and Life Sciences, 1*(1), 69-97.

Dovers, S.R., & Handmer, J.W. (1992). Uncertainty, sustainability and change. *Global Environmental Change, 2*(4), 262-276.
Durkin, M.E. (1984). *The economic recovery of small businesses after earthquakes: The Coalinga experience*: Vigyan Bhavan (Government House).
Dynes, R.R. (1974). Organized behavior in disaster: Disaster Research Center, Ohio State University.
Dyson, K. (1983). The cultural, ideological and structural context. *Industrial Crisis; A Comparative Study of the State and Industry, Oxford*, 26-66.
Earthquake Commission. (2011). *EQC's earthquake liability revised upwards - Finance Minister Bill English*. Christchurch: Earthquake Commission Retrieved from http://canterbury.eqc.govt.nz/news/release/2011/08/eqcs-earthquake-liability-revised-upwards-finance-minister-bill-english.
Eden, C., & Ackermann, F. (2001). Strategic options development and analysis: The principles.
Edmunds, R., Feldman, J.A., Hicks, B.J., & Mullineux, G. (2010). Constraint-based modelling and optimization to support the design of complex multi-domain engineering problems. *Engineering with Computers*, 1-18.
Eidinger, J., Tang, A., & O'Rourke, T. (2010). Report of the 4 September 2010 Mw 7.1 Canterbury (Darfield), New Zealand Earthquake (pp. 1-49).
Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review*, 532-550.
Eisenhardt, K.M., & Graebner, M.E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal, 50*(1), 25.
Elms, D.G. (1985). *The principle of consistent crudeness*.
Elms, D.G. (1998). System health approaches for risk management and design. *Structural Safety and Reliability: Proc. ICOSSAR, 97*, 271-277.
Elms, D.G., Dewhirst, R., McCahon, I., & Kachali, H. (2012). Grey District Readiness for a Major Catastrophic Event.
Evan, W.M. (1965). The Organisation Set: Toward a Theory of Interorganisational Relations. *Management Science, 11*(10), 217-230.
Evan, W.M. (1978). *Interorganizational relations: selected readings*: Univ of Pennsylvania Pr.
Evan, W.M., & Black, G. (1967). Innovation in business organizations: some factors associated with success or failure of staff proposals. *Journal of business, 40*(4), 519-530.
Exner, O., & Zvara, K. (1999). Coefficient of determination in some atypical situations: use in chemical correlation analysis. *Journal of physical organic chemistry, 12*(2), 151-156.
Fallara, P. (2003). Disaster recovery planning. *Potentials, IEEE, 22*(5), 42-44.
Faulkner, B. (2003). Towards a framework for tourism disaster management. *Progressing Tourism Research. Clevedon, S*, 244-268.
Ferrier, W.J., Smith, K.G., & Grimm, C.M. (1999). The role of competitive action in market share erosion and industry dethronement: A study of industry leaders and challengers. *Academy of Management Journal, 42*(4), 372-388.
Fiksel, J. (2006). Sustainability and resilience: toward a systems approach. *Sustainability: Science Practice and Policy, 2*(2), 14-21.
Finch, P. (2004). Supply Chain Risk Management. *Supply Chain Management: An International Journal, 9*(2), 183-196.
Fink, S.L., Beak, J., & Taddeo, K. (1971). Organizational crisis and change. *The Journal of Applied Behavioral Science, 7*(1), 15.

Flood, R.L., & Romm, N.R.A. (1996). *Critical systems thinking: current research and practice*: Springer.
Folke, C., Carpenter, S.R., Elmqvist, T., Gunderson, L., Holling, C.S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment, 31*(5), 437-440.
Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., & Holling, C.S. (2004). Regime shifts, resilience, and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution, and Systematics, 35*, 557-581.
Forrester, J.W. (1969). Urban dynamics.
Forrester, J.W. (1994). System dynamics, systems thinking, and soft OR. *System Dynamics Review, 10*(2 - 3), 245-256.
Foster, H.D. (1997). *The Ozymandias Principles: Thirty-one strategies for surviving change*: Southdowne Press.
Foster, S.P., & Dye, K. (2005). Building continuity into strategy. *Journal of Corporate Real Estate, 7*(2), 105-119.
Freudenberg, M. (2003). Composite indicators of country performance: a critical assessment: OECD Publishing.
Furlong, S.R., & Scheberle, D. (1998). Earthquake Recovery. *The American Review of Public Administration, 28*(4), 367.
Galbraith, C.S., & Stiles, C.H. (2006). Disasters and entrepreneurship: A short review. *Developmental Entrepreneurship: Adversity, Risk, and Isolation, 5*, 147-166.
Geonet. (2010). Earthquake, http://www.geonet.org.nz/earthquake/index.html.
GeoNet. (2011). M 6.3, Christchurch, February 22 2011. Christchurch.
Gerbing, D.W., & Anderson, J.C. (1988). An updated paradigm for scale development incorporating unidimensionality and its assessment. *Journal of marketing research*, 186-192.
Gharajedaghi, J. (1999). *Systems thinking: Managing chaos and complexity: A platform for designing business architecture*: Elsevier.
Giovinazzi, S., & Wilson, T. (2012). "Recovery of Lifelines" following the 22nd February 2011 Christchurch Earthquake: successes and issues. *NZSEE*.
Gladwell, M. (2000). *The tipping point: How little things can make a big difference*: Little, Brown and Company.
Glaser, B.G., & Strauss, A.L. (1967). *The discovery of grounded theory: Strategies for qualitative research*: Aldine de Gruyter.
Godschalk, D.R. (2003). Urban hazard mitigation: Creating resilient cities. *Natural Hazards Review, 4*, 136.
Godschalk, D.R., & Brower, D.J. (1985). Mitigation strategies and integrated emergency management. *Public Administration Review, 45*, 64-71.
Goldratt, E.M., & Cox, J. (1989). *The goal*: Gower.
Gordon, P., Richardson, H.W., & Davis, B. (1998). Transport-related impacts of the Northridge earthquake. *Journal of Transportation and Statistics, 1*(2), 21-36.
Graham, A.K. (2001). Challenge your balanced scorecard. *Credit Union Executive Journal, 41*(3), 22-27.
Gunasekaran, A., Love, P.E.D., Rahimi, F., & Miele, R. (2001). A model for investment justification in information technology projects. *International Journal of Information Management, 21*(5), 349-364.
Guthrie, J.P. (2001). High-involvement work practices, turnover, and productivity: Evidence from New Zealand. *Academy of management Journal*, 180-190.
Haas, J.E., Kates, R.W., & Bowden, M.J. (1977). *Reconstruction following disaster*.

Hall, A.D. (1962). A methodology for systems engineering.
Hamel, G., & Prahalad, C.K. (1996). *Competing for the Future*: Harvard Business Press.
Hamel, G., & Välikangas, L. (2003). The Quest for Resilience. *Harvard Business Review, 81*(9), 52-65.
Hammer, M., Champy, J., Daniels, A.C., James, P.O.S., & Hughes, A.M. (1994). *Reengineering the corporation*: Harper Business New York.
Handler, W.C., & Kram, K.E. (2004). Succession in family firms: The problem of resistance. *Family Business Review, 1*(4), 361-381.
Handmer, J.W., & Dovers, S.R. (1996). A typology of resilience: rethinking institutions for sustainable development. *Organization & Environment, 9*(4), 482.
Harland, C.M. (1996). Supply chain management: relationships, chains and networks. *British Journal of management, 7*, S63-S80.
Harter, R., Petty, J., & Kelly, J. (2006). *Conducting Surveys when Disaster Strikes*.
Haviland, W.A., Walrath, D., & El Prins, H. (2007). *Cultural Anthropology The Human Challenge*: Thomson Learning.
Heinrich, H.W., Petersen, D., & Roos, N. (1950). *Industrial accident prevention*: McGraw-Hill New York.
Heinzl, H., & Mittlbock, M. (2003). Pseudo R-squared measures for Poisson regression models with over-or underdispersion. *Computational statistics & data analysis, 44*(1), 253-271.
Helmreich, R.L., Klinect, J.R., & Wilhelm, J.A. (1999). *Models of threat, error, and CRM in flight operations*.
Hewitt, K. (1997). *Regions of risk: A geographical introduction to disasters*: Longman Harlow.
Hills, A. (2002). Seduced by recovery: The consequences of misunderstanding disaster. *Journal of Contingencies and Crisis Management, 6*(3), 162-170.
Holland, J.H. (1992). Complex adaptive systems. *Daedalus, 121*(1), 17-30.
Holling, C.S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics, 4*, 1-23.
Hollnagel, E., Woods, D.D., & Leveson, N.G. (2006). *Resilience engineering: Concepts and precepts*: Ashgate Pub Co.
Hopkins, A. (2007). The Problem of Defining High Reliability Organisations. *National Reseatch Centre for OHS Regulation-Working Paper, 51*, 1-15.
Horne, J.F., & Orr, J.E. (1998). Assessing behaviors that create resilient organizations. *Employment Relations Today, 24*, 29-40.
Hummel, R., Ahlers, D., Science, Belfer Center for, & Affairs, International. (2007). *Lessons from Katrina: How a Community Can Spearhead Successful Disaster Recovery*: The Broadmoor Project, Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University.
Hunton, J.E., Libby, R., & Mazza, C.L. (2006). Financial reporting transparency and earnings management. *Accounting Review*, 135-157.
Isaac, A. (1997). The Cave Creek incident: a REASONed explanation. *The Australasian Journal of Disaster and Trauma Studies, 3*.
Jacques, R. (1996). *Manufacturing the employee: Management knowledge from the 19th to 21st centuries*: Sage Publications Ltd.
Jaeger, P.T., Shneiderman, B., Fleischmann, K.R., Preece, J., Qu, Y., & Fei Wu, P. (2007). Community response grids: E-government, social networks, and effective emergency management. *Telecommunications Policy, 31*(10-11), 592-604.

Jarvis, C.B., MacKenzie, S.B., & Podsakoff, P.M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of consumer research, 30*(2), 199-218.

Jensen, A.R. (1980). Bias in mental testing.

Jick, T.D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly*, 602-611.

Johannessen, J.A. (1998). Organisations as social systems: the search for a systemic theory of organisational innovation processes. *Kybernetes, 27*(4), 359-387.

Johnson, J. (2013). Safeguarding New Zealand's Economy and Communities – Insurance Industry Opportunities and Challenges. http://icnz.org.nz/safeguarding-new-zealands-economy-and-communities-insurance-industry-opportunities-and-challenges/

Johnson, R.A., Kast, F.E., & Rosenzweig, J.E. (1964). Systems theory and management. *Management Science, 10*(2), 367-384.

Jolly, A. (Ed.). (2003). *Managing Business Risk: A practical guide to protecting your business.*

Kachali, H., Stevenson, J.R., Whitman, Z.R., Seville, E.P., Vargo, J.J., & Wilson, T.M. (2012). Organisational Resilience and Recovery for Canterbury Organisations after the 4 September 2010 Earthquake. *Australasian Journal of Disaster and Trauma Studies, 2012*(1), 11-19.

Kaiapoi Promotion Association Inc (Producer). (2012, 9 July 2012). Brief history. Retrieved from http://www.kaiapoi.org.nz/brief-history.html

Kanji, G.K. (1998). Measurement of business excellence. *Total Quality Management & Business Excellence, 9*(7), 633-643.

Kanji, G.K., & Moura e Sa, P. (2001). Measuring leadership excellence. *Total Quality Management & Business Excellence, 12*(6), 701-718.

Kanji, G.K., & Wallace, W. (2000). Business excellence through customer satisfaction. *Total Quality Management & Business Excellence, 11*(7), 979-998.

Kaplan, R.S., & Garrick, B.J. (1981). On the quantitative definition of risk. *Risk analysis, 1*(1), 11-27.

Kaplan, R.S., & Norton, D.P. (1992). The balanced scorecard-measures that drive performance. *Harvard Business Review, 70*(1), 71-79.

Kaplan, R.S., & Norton, D.P. (1996a). Using the balanced scorecard as a strategic management system. *Harvard Business Review, 74*(1), 75-85.

Kaplan, R.S., & Norton, D.P. (1996b). *The balanced scorecard: Translating strategy into action*: Harvard Business Press.

Kaplan, R.S., & Norton, D.P. (2004b). Measuring the strategic readiness of intangible assets. *Harvard Business Review, 82*(2), 52-63.

Kates, R.W., & Pijawka, D. (1977). From rubble to monument: the pace of reconstruction. *Reconstruction Following Disaster*, 1,Äì23.

Kay, R., & Goldspink, C. (2012). Research paper 1: CEO perspectives on organisational resilience.

Kelly, D., & Amburgey, T.L. (1991). Organizational inertia and momentum: A dynamic model of strategic change. *Academy of Management Journal, 34*(3), 591-612.

Kelly, K. (1995). *Out of control*: Addison-Wesley Reading, Mass.

Khatri, N., & D'Netto, B. (1995). *Perceived uncertainty and performance: the causal direction*: Nanyang Technological University, School of Accountancy and Business.

Kim, D.H. (1996). The link between individual and organizational learning. *How Organizations Learn–Managing the Search for Knowledge*, 29-50.

Kleindorfer, P.R., & Saad, G.H. (2005). Managing disruption risks in supply chains. *Production and Operations Management, 14*(1), 53-68.
Knight, R.F., & Pretty, D.J. (1996). *The impact of catastrophes on shareholder value*: Templeton College.
Kondrasuk, J.N. (2004). The effects of 9/11 and terrorism on human resource management: Recovery, reconsideration, and renewal. *Employee Responsibilities and Rights Journal, 16*(1), 25-35.
Korsching, P.F., & Allen, J.C. (2004). Locality based entrepreneurship: A strategy for community economic vitality. *Community Development Journal, 39*(4), 385.
Kroll, C.A. (1991). *Economic impacts of the Loma Prieta earthquake: A focus on small business*: Center for Real Estate and Urban Economics, University of California, Berkeley.
Kroll, C.A., Landis, J.D., Shen, Q., & Stryker, S. (1991). Economic impacts of the Loma Prieta Earthquake: a focus on small businesses. In U. C. T. C. a. t. C. f. R. E. a. U. Economics (Ed.). Berkeley, CA: University of California at Berkeley.
Kruse, C. (1993). Disaster plan stands test of hurricane. *Personnel Journal, 72*(6), 36-36.
Kunreuther, H. (1996). Mitigating disaster losses through insurance. *Journal of risk and Uncertainty, 12*(2), 171-187.
Kunreuther, H. (2006). Has the time come for comprehensive natural disaster insurance? *On Risk and Disaster: Lessons from Hurricane Katrina, 175*, 175.
Kunreuther, H. (2008). Reducing losses from catastrophic risks through long-term insurance and mitigation. *Social Research: An International Quarterly, 75*(3), 905-930.
Kunreuther, H., & Fiore, E.S. (1966). The Alaskan earthquake: A case study in the economics of disaster: DTIC Document.
Kvale, S. (1996). *InterViews. An introduction to qualitative research writing*: Sage Publications, Thousand Oaks, CA.
Kvalseth, T.O. (1985). Cautionary note about R2. *American Statistician*, 279-285.
La Porte, T.R., & Consolini, P.M. (1991). Working in practice but not in theory: theoretical challenges of" high-reliability organizations". *Journal of Public Administration Research and Theory, 1*(1), 19.
Lambert, D.M., & Cooper, M.C. (2000). Issues in supply chain management. *Industrial marketing management, 29*(1), 65-83.
Lansing, J.S. (2003). Complex adaptive systems. *Annual Review of Anthropology, 32*, 183-204.
Laplante, P. A. (2007). *What every engineer should know about software engineering*: CRC Press.
Lebel, L., Anderies, J.M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T.P., & Wilson, J. (2006). Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society, 11*(1), 19.
Lee, A.V., Vargo, J.J., & Seville, E.P. (2013). Developing a Tool to Measure and Compare Organizations' Resilience. *Natural Hazards Review, 14*(1), 29-41.
Lee Rodgers, J., & Nicewander, W.A. (1988). Thirteen ways to look at the correlation coefficient. *The American Statistician, 42*(1), 59-66.
Lengnick-Hall, C.A., & Beck, T.E. (2005). Adaptive fit versus robust transformation: How organizations respond to environmental change. *Journal of Management, 31*(5), 738.
Levers, J., & Bhatia, S. (2011). Recovery as a Catalyst for Reducing Risk International Recovery Platform Global Assessment Report 2011: International Recovery Platform.
Leveson, N.G. (1986). Software safety: Why, what, and how. *ACM Computing Surveys (CSUR), 18*(2), 163.

Leveson, N.G. (2002). System safety engineering: Back to the future. *Massachusetts Institute of Technology*.
Leveson, N.G. (2010). Applying systems thinking to analyze and learn from events. *Safety Science*.
Leveson, N.G., Dulac, N., Marais, K., & Carroll, J. (2009). Moving beyond normal accidents and high reliability organizations: a systems approach to safety in complex systems. *Organization Studies, 30*(2-3), 227-249.
Levin, S.A. (1998). Ecosystems and the biosphere as complex adaptive systems. *Ecosystems, 1*(5), 431-436.
Lindgreen, A., & Swaen, V. (2010). Corporate social responsibility. *International Journal of Management Reviews, 12*(1), 1-7.
Maguire, B. (2007). Disasters and communities: understanding social resilience. *Australian Journal of Emergency Management, 22*(2), 16-20.
Majumder, S. (2005). Sri Lanka's tourism beset by problems, *BBC*. Retrieved from http://news.bbc.co.uk/2/hi/south_asia/4360771.stm
Malotaux, N. (2008). Recognizing and Understanding Human Behavior to Improve Systems Engineering Results. In N. R. Malotaux-Consultancy (Ed.).
Manson, S.M. (2001). Simplifying complexity: a review of complexity theory. *Geoforum, 32*(3), 405-414.
Manyena, S.B. (2006). The concept of resilience revisited. *Disasters, 30*(4), 434-450.
Markides, C.C., & Williamson, P.J. (1994). Related diversification, core competences and corporate performance. *Strategic Management Journal, 15*(S2), 149-165.
Martin, P.Y., & Turner, B.A. (1986). Grounded theory and organizational research. *The Journal of Applied Behavioral Science, 22*(2), 141-157.
Maslow, A.H. (1954). Motivation and Personality. *New York: Haper & Brothers*.
Mayunga, J.S. (2007). Understanding and applying the concept of community disaster resilience: A capital-based approach. *Summer Academy for Social Vulnerability and Resilience Building*, 1-16.
McManus, S.T. (2008). *Organisational Resilience in New Zealand*.
McManus, S.T., Seville, E.P., Vargo, J.J., & Brunsdon, D. (2008). Facilitated process for improving organizational resilience. *Natural Hazards Review, 9*(2), 81-90.
Meadows, D.H., & Wright, D. (2008). *Thinking in systems: A primer*: Chelsea Green Publishing.
Meadows, L.M., & Morse, J.M. (2001). Constructing evidence within the qualitative project. *The nature of qualitative evidence*, 187-200.
Merton, R.K. (1967). *On theoretical sociology: five essays, old and new*: Free Press New York.
Mileti, D.S. (2005). Disasters by design. *Economics and the wind*, 1.
Mileti, D.S., & O'Brien, P. (1993). Public response to aftershock warnings. *US Geological Survey Professional Paper, 1553*, 31-42.
Mileti, D.S., & Sorensen, J.H. (1987). Natural hazards and precautionary behavior. *Taking care: Understanding and encouraging self-protective behavior*, 189-207.
Miller, M., Paton, D., & Johnston, D.M. (1999). Community vulnerability to volcanic hazard consequences. *Disaster Prevention and Management, 8*(4), 255-260.
Mills, C.W. (1959). *The sociological imagination*: Oxford University Press, USA.
Minitab Inc. (2012). Minitab 16 assistant white paper.
Mitleton-Kelly, E. (2003). Ten principles of complexity and enabling infrastructures. *Complex systems and evolutionary perspectives on organisations: The application of complexity theory to organisations*, 23ñ50.
Mitroff, I.I. (2004). Think like a sociopath, act like a saint. *Journal of Business Strategy, 25*(5), 42-53.

Mitroff, I.I. (2005). *Why some companies emerge stronger and better from a crisis: 7 essential lessons for surviving disaster*: Amacom Books.
Mitroff, I.I., Alpaslan, M.C., & Green, S.E. (2004). Crises as Ill Structured Messes. *International Studies Review, 6*(1), 165-194.
Mitroff, I.I., Shrivastava, P., & Udwadia, F.E. (1987). Effective crisis management. *The Academy of Management Executive (1987-1989), 1*(4), 283-292.
Mount, J., Zinger, J.T., & Forsyth, G.R. (1993). Organizing for development in the small business. *Long range planning, 26*(5), 111-120.
Munich Re. (1999). A Year, a Century, and a Millennium of Natural Catastrophes are all nearing their End. *Press release of December, 20*, 1999.
Munich Re (Producer). (2012). Munich Re posts €0.71bn profit for challenging year 2011 - Stable dividend. Retrieved from http://www.munichre.com/en/media_relations/press_releases/2012/2012_02_02_press_release.aspx
Nakagawa, Y., & Shaw, R. (2004). Social capital: A missing link to disaster recovery. *International Journal of Mass Emergencies and Disasters, 22*(1), 5-34.
Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., & Giovannini, E. (2005). Handbook on constructing composite indicators: methodology and user guide: OECD Publishing.
National Road Carriers Inc (Producer). (2012, 9 July 2012). Retrieved from http://www.transport.org.nz/Section?Action=View&Section_id=45
Neely, A.D., Adams, C., & Kennerley, M. (2002). *The Performance Prism: The scorecard for measuring and managing business success*: Financial Times/Prentice Hall London, UK.
Neely, A.D., Gregory, M., & Platts, K. (2005). Performance measurement system design: a literature review and research agenda. *International Journal of Operations & Production Management, 25*(12), 1228-1263.
Nemet, G.F. (2009). Demand-pull, technology-push, and government-led incentives for non-incremental technical change. *Research Policy, 38*(5), 700-709.
New Zealand Department of Treasury. (2002). Low wage jobs and pathways to better outcomes. Retrieved 9 July 2012, from http://www.treasury.govt.nz/publications/research-policy/wp/2002/02-29/24.htm
New Zealand Historic Places Trust. (2009). Lyttelton Township Historic Area.
New Zealand Historic Places Trust. (2012). Canterbury Region, Pekenga - Ngā Pakihi Whakatikatika o Waitaha.
New Zealand Information and Communication Technologies Group. (2010). NZICT sets the direction for the ICT and hi-tech sector.
New Zealand Institute of Economic Research. (2010). Slowing recovery.
New Zealand Ministry for the Environment. (2012). Transport in New Zealand.
New Zealand Ministry of Civil Defence and Emergency Management. (2012). *Lifeline utilities*. Retrieved from http://www.civildefence.govt.nz/memwebsite.nsf/srch/75BCEDA70F3B890FCC257A55000EF953?OpenDocument.
New Zealand Ministry of Civil Defence and Emergency Management. (2012b). CDEM & the role of Fast Moving Consumer Goods in a resilient New Zealand.
New Zealand Transport Agency. (2012b). Road user charges.

Newlove, L., Stern, E., & Svedin, L. (2003). *Auckland unplugged: coping with critical infrastructure failure*: Lexington Books.
Nigg, J.M., & Tierney, K.J. (1990). Explaining differential outcomes in the small business disaster loan application process.
Nordhaus, W.D. (1973). World dynamics: measurement without data. *The Economic Journal, 83*(332), 1156-1183.
Norwood, A.E., & Ursano, R.J. (1997). Psychiatric intervention in post-disaster recovery. *Directions in Psychiatry, 17*, 247-262.
Nystrom, P.C., & Starbuck, W.H. (1981). *Handbook of Organizational Design: Remodeling organizations and their environments*: Oxford University Press.
O'Brien, G., O'Keefe, P., Gadema, Z., & Swords, J. (2010). Approaching disaster management through social learning. *Disaster Prevention and Management, 19*(4), 498-508.
OED. (Ed.) (2010) Oxford English Dictionary.
Okuyama, Y. (2003). Economics of natural disasters: A critical review. *Research Paper, 12*.
Olshansky, R.B. (2006). Planning after hurricane Katrina. *Journal of the American Planning Association, 72*(2), 147-153.
Olshansky, R.B., & Johnson, L.A. (2012). Clear as Mud: Planning for the Rebuilding of New Orleans. *Publius: The Journal of Federalism*.
Olshansky, R.B., Johnson, L.A., & Topping, K.C. (2006). Rebuilding communities following disaster: Lessons from Kobe and Los Angeles. *Built Environment, 32*(4), 354-374.
Ota, T., Maki, N., & Hayashi, H. (2009). Evaluating Planning Process of the Kobe Recovery Plan Based on Project Management Framework. *Journal ref: Journal of Disaster Research, 4*(3), 271-281.
Palen, L., & Liu, S.B. (2007). *Citizen communications in crisis: anticipating a future of ICT-supported public participation*.
Pascale, R.T., & Athos, A.G. (1981). The art of Japanese management. *Business Horizons, 24*(6), 83-85.
Pasmore, W.A. (1994). *Creating strategic change: Designing the flexible, high-performing organization*: John Wiley & Sons Inc.
Pathak, S.D., Day, J.M., Nair, A., Sawaya, W.J., & Kristal, M.M. (2007). Complexity and Adaptivity in Supply Networks: Building Supply Network Theory Using a Complex Adaptive Systems Perspective*. *Decision Sciences, 38*(4), 547-580.
Paton, D. (2006). Disaster Resilience: Integrating individual, community, institutional and environmental perspectives. *Disaster resilience: An integrated approach, 320*.
Paton, D. (2007). *Measuring and monitoring resilience in Auckland* (Vol. 2007/18). Wellington: GNS Science.
Paton, D., & Johnston, D.M. (2006). *Disaster resilience: an integrated approach*: Charles C. Thomas Publisher.
Paton, D., Johnston, D.M., & Houghton, B.F. (1998). Organisational Response to a Volcanic Eruption. *Disaster Prevention and Management, 7*(1), 5-13.
Pearson, C.M., & Clair, J.A. (1998). Reframing crisis management. *Academy of Management review, 23*(1), 59-76.
Pearson, C.M., & Mitroff, I.I. (1993). From crisis prone to crisis prepared: A framework for crisis management. *The Executive, 7*(1), 48-59.
Pentland, B.T., & Reuter, H.H. (1994). Organizational routines as grammars of action. *Administrative Science Quarterly, 39*(3).
Perrings, C. (1998). Resilience in the dynamics of economy-environment systems. *Environmental and Resource Economics, 11*(3), 503-520.

Perrow, C. (1984). *Normal accidents*.
Perrow, C. (1986). The habit of courting disaster, *The Nation,* pp. 329-356.
Perrow, C. (1994). The limits of safety: the enhancement of a theory of accidents. *Journal of Contingencies and crisis management, 2*(4), 212-220.
Perrow, C. (1999). *Normal accidents: Living with high-risk technologies*: Princeton Univ Pr.
Perz, S.G. (2007). Grand theory and context-specificity in the study of forest dynamics: forest transition theory and other directions. *The Professional Geographer, 59*(1), 105-114.
Petak, W. (2002). Earthquake resilience through mitigation: a system approach. *International Institute for Applied Systems Analysis, Laxenburg, Austria*.
Peters, T., & Waterman, R. (1982). In search of excellence: Lessons from Americaís best-run corporations: New York: Harper and Row.
Pidgeon, N.F., & Harwood, K. (1996). Handbook of Qualitative research: Methods for Psychology and the Social Sciences Grounded Theory: practical Implementation. *Leicester: British Psychological Society, Brooks*.
Pinto, J.K., & Prescott, J.E. (1988). Variations in critical success factors over the stages in the project life cycle. *Journal of management, 14*(1), 5-18.
Popp, A. (2006). The effects of natural disasters on long run growth. *Major Themes in Economics, 1*, 61-81.
Porter, M.E. (1998). *Competitive Advantage: Creating and Sustaining Superior Performance*: The Free Press.
Porter, M.E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic development quarterly, 14*(1), 15-34.
Powell, F., & Harding, A. (2009). Business Recovery and the Rebuilding of Commercial Property.
Powell, T.C. (1991). Shaken, but alive: organizational behavior in the wake of catastrophic events. *Organization & Environment, 5*(4), 271-291.
Pretty, D.J., & Knight, R.F. (2002). Risks that matter. In O. Metrica (Ed.).
Prud'homme, A.M.G. (2008). Business continuity in the supply chain: Planning for disruptive events.
Pugsley, A.G. (1973). The prediction of proneness to structural accidents. *The structural engineer, 51*(6), 195-196.
Quarantelli, E.L. (1982a). Sheltering and housing after major community disasters: case studies and general observations.
Quarantelli, E.L. (1982b). What is a disaster? An agent specific or an all disaster spectrum approach to socio-behavioral aspects of earthquakes?
Quarantelli, E.L. (1986). Organizational Behavior in Disasters and Implications for Disaster Planning. Volume 1, Number 2: DTIC Document.
Quarantelli, E.L. (1988). Disaster crisis management: A summary of research findings. *Journal of Management Studies, 25*(4), 373-385.
Quarantelli, E.L. (1999). The disaster recovery process: What we know and do not know from research.
Quarantelli, E.L. (2006). Catastrophes are different from disasters: Some implications for crisis planning and managing drawn from Katrina. *Understanding Katrina: Perspectives from the social sciences*.
REAG. (2011). Organisational Resilience Position Paper for Critical Infrastructure: Australian Resilience Expert Advisory Group.

Reason, J. (1998). Achieving a safe culture: Theory and practice. *Work & Stress, 12*(3), 293-306.
Reason, J. (2000). Human error: Models and management. *Bmj, 320*(7237), 768.
Reason, J., Hollnagel, E., & Paries, J. (2006). Revisiting the Swiss Cheese Model of Accidents. *Journal of Clinical Engineering, 27*, 110-115.
Resilience Alliance. (2012). Resilience. Retrieved 19th February, 2012, from http://www.resalliance.org/index.php/resilience
Resilient Organisations. (2010a). Benchmark Resilience Tool.
Resilient Organisations. (2010b). Organisational Resilience Measurement Tool.
Resilient Organisations (Producer). (2011). Strategic Objectives. Retrieved from http://www.resorgs.org.nz/
Reynolds, M., & Holwell, S. (2010). Introducing systems approaches. *Systems Approaches to Managing Change: A Practical Guide*, 1-23.
Richards, L., & Morse, J. (2007). README FIRST for a User's Guide to Qualitative Research: Sage Publishers.
Richardson, G.P., & Pugh III, A.I. (1981). *Introduction to system dynamics modeling with DYNAMO*: Productivity Press Inc.
Richmond, B. (1994). *System Dynamics/systems thinking: Let's just get on with it*.
Roberts, K.H. (1990). Some characteristics of one type of high reliability organization. *Organization Science, 1*(2), 160-176.
Robson, C. (2002). *Real world research: A resource for social scientists and practitioner-researchers*: Wiley-Blackwell.
Rockhart, J.F., & Bullen, C.V. (1981). A primer on critical success factors.
Romano, C.A. (1989). Research strategies for small business: a case study approach. *International Small Business Journal, 7*(4), 35.
Rose, A. (2004). Defining and measuring economic resilience to disasters. *Disaster Prevention and Management, 13*(4), 307-314.
Rose, A., Benavides, J., Chang, S.E., Szczesniak, P., & Lim, D. (1997). The regional economic impact of an earthquake: Direct and indirect effects of electricity lifeline disruptions. *Journal of Regional Science, 37*(3), 437-458.
Rose, A., & Lim, D. (2002). Business interruption losses from natural hazards: conceptual and methodological issues in the case of the Northridge earthquake. *Global Environmental Change Part B: Environmental Hazards, 4*(1), 1-14.
Rubin, C.B. (2009). Long Term Recovery from Disasters - The Neglected Component of Emergency Management. *Journal of Homeland Security and Emergency Management, 6*(1), 46.
Rubin, C.B., & Barbee, D.G. (1985). Disaster recovery and hazard mitigation: Bridging the intergovernmental gap. *Public Administration Review, 45*, 57-63.
Rummler, G.A., & Brache, A.P. (1990). *Improving performance*: Jossey-Bass San Francisco.
Runyan, R.C. (2006). Small Business in the Face of Crisis: Identifying Barriers to Recovery from a Natural Disaster1. *Journal of Contingencies and crisis management, 14*(1), 12-26.
Sanchez, J.I., Korbin, W.P., & Viscarra, D.M. (1995). Corporate support in the aftermath of a natural disaster: Effects on employee strains. *Academy of Management Journal*, 504-521.
Sato, K., & Hoshino, Y. (1984). *The Anatomy of Japanese business*: ME Sharpe Inc.
Schlicht, E., & Thompson, J.J. (1985). *Isolation and aggregation in economics*: Springer.
Senge, P.M. (1998). The practice of innovation. *Leader to leader, 1998*(9), 16-22.
Senge, P.M. (2006). *The fifth discipline: The art and practice of the learning organization*: Broadway Business.
Senge, P.M., Scharmer, C.O., & Flowers, B.S. (2005). *Presence: Exploring profound change in people, organizations, and society*: Broadway Business.

Senge, P.M., & Sterman, J.D. (1992). Systems thinking and organizational learning: Acting locally and thinking globally in the organization of the future. *European Journal of Operational Research, 59*(1), 137-150.
Seville, E.P., Brunsdon, D., Dantas, A., Le Masurier, J., Wilkinson, S., & Vargo, J.J. (2008). Organisational resilience: Researching the reality of New Zealand organisations. *Journal of Business Continuity & Emergency Planning, 2*(2), 258-266.
Sheffi, Y. (2007). The resilient enterprise: Overcoming vulnerability for competitive advantage. *MIT Press Books, 1*.
Sheffi, Y., & Rice, J.B. (2005). A supply chain view of the resilient enterprise. *MIT Sloan Management Review, 47*(1), 41.
Shrivastava, P. (1994). The evolution of research on technological crises in the US. *Journal of Contingencies and crisis management, 2*(1), 10-20.
Shrivastava, P., Mitroff, I.I., Miller, D., & Miclani, A. (1988). Understanding Industrial Crises. *Journal of Management Studies, 25*(4), 285-303.
Simon, H.A. (1991). Bounded rationality and organizational learning. *Organization Science, 2*(1), 125-134.
Sirkin, H.L., Hemerling, J.W., & Bhattacharya, A.K. (2008). *Globality: Competing with everyone from everywhere for everything*: Business Plus.
Skinner, Q. (1990). *The return of grand theory in the human sciences*: Cambridge Univ Pr.
Smith, D, & Sipika, C. (1993). Back from the brink--post-crisis management. *Long range planning, 26*(1), 28-38.
Smith, D. (1990). Beyond contingency planning: towards a model of crisis management. *Organization & Environment, 4*(4), 263.
Smith, G.P., & Wenger, D. (Eds.). (2007). *Sustainable Disaster Recovery: Operationalizing an Existing Agenda*: NY: Springer.
Smith, S.D. (2004). Inter-agency collaboration and consequence management: an all-hazard approach to emergency incident response: Fairfax, Virginia: Public Entity Risk Institute.
Sneppen, K., Bak, P., Flyvbjerg, H., & Jensen, M.H. (1995). Evolution as a self-organized critical phenomenon. *Proceedings of the National Academy of Sciences of the United States of America, 92*(11), 5209.
Sommerville, I. (Producer). (2000). Requirements Engineering - An Overview.
Spathis, C.T. (2002). Detecting false financial statements using published data: some evidence from Greece. *Managerial Auditing Journal, 17*(4), 179-191.
Spittal, M.J., McClure, J., Siegert, R.J., & Walkey, F.H. (2005). Optimistic bias in relation to preparedness for earthquakes. *Australasian Journal of Disaster and Trauma Studies, 1*, 1-10.
Spittal, M.J., McClure, J., Siegert, R.J., & Walkey, F.H. (2008). Predictors of two types of earthquake preparation. *Environment and Behavior, 40*(6), 798-817.
Stacey, R.D. (1995). The science of complexity: An alternative perspective for strategic change processes. *Strategic Management Journal, 16*(6), 477-495.
Starr, R., Newfrock, J., & Delurey, M. (2003). Enterprise resilience: managing risk in the networked economy. *Strategy and Business*, 70-79.
Statistics New Zealand. (2011a). Business Demography Statistics.
Statistics New Zealand. (2011d). Electronic Card Transactions: July 2011.
Statistics New Zealand. (2012d). Electronic Card Transactions: February 2012.
Statistics New Zealand. (2012e). *New Zealand Business Demography Statistics: At February 2012*. New Zealand: Retrieved from

http://www.stats.govt.nz/browse_for_stats/businesses/business_characteristics/BusinessDemographyStatistics_HOTPFeb12/Commentary.aspx.

Staw, B.M., Sandelands, L.E., & Dutton, J.E. (1981). Threat Rigidity Effects in Organizational Behavior: A Multilevel Analysis. *Administrative Science Quarterly*, 501-524.

Stephenson, A.V. (2010). *Benchmarking The Resilience Of Organisations.* (Doctor of Philosophy), University of Canterbury, Christchurch.

Sterman, J.D. (1984). Appropriate summary statistics for evaluating the historical fit of system dynamics models. *Dynamica, 10*(2), 51-66.

Sterman, J.D. (1989). Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment. *Management science*, 321-339.

Sterman, J.D. (1994). Learning in and about complex systems. *System Dynamics Review, 10*(2-3), 291-330.

Sterman, J.D. (2000). *Business dynamics: Systems thinking and modeling for a complex world*: Irwin/McGraw-Hill.

Sterman, J.D. (2002). All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review, 18*(4), 501-531.

Stern, E. (1997). Crisis and learning: A conceptual balance sheet. *Journal of Contingencies and crisis management, 5*(2), 69-86.

Stern, E., & Sundelius, B. (2002). Crisis management Europe: An integrated regional research and training program. *International Studies Perspectives, 3*(1), 71-88.

Stevens, G.C. (1989). Integrating the Supply Chain. *International Journal of Physical Distribution & Logistics Management, 19*(8), 3-8.

Strauss, A.L., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques* (Vol. 15): Sage Newbury Park, CA.

Strauss, A.L., & Corbin, J. (1998). *Basics of qualitative research: Procedures and techniques for developing grounded theory*. Thousand Oaks, CA: Sage.

Suddaby, R. (2006). From the editors: What grounded theory is not. *The Academy of Management Journal Archive, 49*(4), 633-642.

Sutcliffe, K.M., & Vogus, T.J. (2003). Organizing for resilience. *Positive organizational scholarship: Foundations of a new discipline*, 94-110.

Swiss Re. (2011). Sigma – preliminary estimates for 2011: natural catastrophes and man-made disasters caused economic losses of USD 350 billion and cost insurers USD 108 billion.

Tabachnick, B.G., Fidell, L.S., & Osterlind, S.J. (2001). *Using multivariate statistics*: Pearson.

Taleb, N.N. (2007). *The black swan: The impact of the highly improbable*: Random House Trade Paperbacks.

Thain, D.H., & Goldthorpe, R.C. (1989). Turnaround management: causes of decline. *Business Quarterly, 54*(1), 55-62.

The Greater Christchurch Urban Development Strategy. (2012). *The Greater Christchurch Urban Development Strategy*. Retrieved from http://www.greaterchristchurch.org.nz/.

Thomke, S., Von Hippel, E., & Franke, R. (1998). Modes of experimentation: an innovation process--and competitive--variable. *Research Policy, 27*(3), 315-332.

Tierney, K.J. (1993a). Business vulnerability and disruption: Data from the 1993 Midwest floods.

Tierney, K.J. (1993b). Disaster preparedness and response: Research findings and guidance from the social science literature.

Tierney, K.J. (1997). Business impacts of the Northridge earthquake. *Journal of Contingencies and crisis management, 5*(2), 87-97.

Tierney, K.J. (2003). Conceptualizing and Measuring Organizational and Community Resilience: Lessons from the Emergency Response Following the September 11, 2001 Attack on the World Trade Center: University of Delaware Disaster Research Center.
Tierney, K.J. (2007a). Businesses and Disasters: Vulnerability, Impacts, and Recovery *Handbooks of Disaster Research* (pp. 275-296).
Tierney, K.J. (2007b). Businesses and Disasters: Vulnerability, Impacts, and Recovery. *Handbook of Disaster Research*, 275-296.
Tierney, K.J. (2008). *Structure and Process in the Study Of Disaster Resilience.*
Tierney, K.J. (2009). Disaster response: Research findings and their implications for resilience measures. *CARRI Research Report, 6*.
Tierney, K.J., & Dahlhamer, J.M. (1997). Business disruption, preparedness and recovery: Lessons from the Northridge earthquake.
Tierney, K.J., & Nigg, J.M. (1995). Business vulnerability to disaster-related lifeline disruption.
Tierney, K.J., & Webb, G.R. (2001). Business Vulnerability to Earthquakes and Other Disasters.
Tonkin & Taylor. (2011). Darfield Earthquake Recovery Geotechnical Factual Report Kaiapoi North.
Turner, B.A. (1976). The organizational and interorganizational development of disasters. *Administrative Science Quarterly, 21*(3), 378-397.
Turner, B.A. (1981). Some practical aspects of qualitative data analysis: one way of organising the cognitive processes associated with the generation of grounded theory. *Quality & Quantity, 15*(3), 225-247.
Turner, B.A. (1983). The use of grounded theory for the qualitative analysis of organizational behaviour. *Journal of Management Studies, 20*(3), 333-348.
Tyhurst, J.S. (1951). Individual reactions to community disaster. *American Journal of Psychiatry, 107*(764-769), 265.
UNISDR. (2005). Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters.
UNISDR. (2009a). from http://www.unisdr.org/eng/terminology/terminology-2009-eng.html
UNISDR (Producer). (2009b). UNISDR Terminology on Disaster Risk Reduction. [Definition] Retrieved from http://www.unisdr.org/we/inform/terminology#letter-r
Walker, B., Holling, C.S., Carpenter, S.R., & Kinzig, A. (2004). Resilience, Adaptability and Transformability in Social--ecological Systems. *Ecology and society, 9*(2), 5.
Walker, B., & Meyers, J.A. (2004). Thresholds in ecological and socialecological systems: a developing database. *Ecology and society, 9*(2), 3.
Webb, G.R., Tierney, K.J., & Dahlhamer, J.M. (2002). Predicting long-term business recovery from disaster: a comparison of the Loma Prieta earthquake and Hurricane Andrew. *Global Environmental Change Part B: Environmental Hazards, 4*(2-3), 45-58.
Weick, K.E. (1987). Organizational culture as a source of high-reliability. *California management review, 29*(2).
Weihs, C. (1993). Multivariate exploratory data analysis and graphics: A tutorial. *Journal of chemometrics, 7*(5), 305-340.
Weinstein, N.D. (1980). Unrealistic optimism about future life events. *Journal of personality and social psychology, 39*(5), 806.
West, C.T., & Lenze, D.G. (1994). Modeling the regional impact of natural disaster and recovery: a general framework and an application to Hurricane Andrew. *International Regional Science Review, 17*(2), 121.

Whitman, Z.R, Stevenson, J.R., Kachali, H., Seville, E.P., Vargo, J.J., & Wilson, T.M. (2014). Organisational Resilience Following the 4 September 2010 Darfield Earthquake. *Disasters, 38*(1).

Whitman, Z.R., Kachali, H., Roger, D., Seville, E.P., & Vargo, J.J. (2013). Development and Validation of a Short-Form for the Benchmark Resilience Tool (BRT-53). *Measuring Business Excellence, 17*(3).

Whitman, Z.R., Wilson, T.M., Stevenson, J.R., Kachali, H., Seville, E.P., & Vargo, J.J. (2011). Rural organisational impact and resilience analysis to natural hazards.

Wildavsky, A.B. (1988). *Searching for safety*: Transaction publishers.

von Bertalanffy, L. (1950). An outline of general system theory. *British Journal for the Philosophy of Science, 1*(2), 134-165.

von Bertalanffy, L. (1972). The history and status of general systems theory. *Academy of Management Journal*, 407-426.

Wu, J.Y., & Lindell, M.K. (2004). Housing Reconstruction After Two Major Earthquakes: The 1994 Northridge Earthquake in the United States and the 1999 Chi,ÄêChi Earthquake in Taiwan. *Disasters, 28*(1), 63-81.

Yin, R.K. (1989). *Case study research*: Sage Publ.

Zellner, A. (1980). Information Sources for Modeling the National Economy: Comment. *Journal of the American Statistical Association, 75*(371), 567-569.

Zolin, R., & Kropp, F. (2007). How surviving businesses respond during and after a major disaster. *Journal of Business Continuity & Emergency Planning, 1*(2), 183-199.

13 Appendices

The complete documents for each appendix are contained in the CD that comes with this work.

13.1.1 **Appendix A** – Informed interview consent form

13.1.2 **Appendix B** - Contextual interview guide

13.1.3 **Appendix C** - Survey 1 results extra tables

13.1.4 **Appendix D** – Survey 2 results extra tables

13.1.5 **Appendix E** – Survey 3 results extra tables

13.1.6 **Appendix F** – Organisational resilience sectoral indicator scores

13.1.7 **Appendix G** – Questions for level of impact and Closure Impact Factor

13.1.8 **Appendix H** – Case Study Interview Guide

13.1.9 **Appendix I** – Additional analysis by organisational size - using full-time equivalent (FTE) staff count

13.1.10 **Appendix J** – Additional Analysis - System Dynamics Quantified Stock and Flow of Organisational Recovery

13.1.11 **Appendix K** – Survey 1 Questionnaire

13.1.12 **Appendix L** – Survey 2 Questionnaire

13.1.13 **Appendix M** - Survey 3 Questionnaire

13.1.14 **Appendix N** – Alternative techniques for arriving at the significant contributors to recovery

13.1.15 **Appendix O - List of additional publications produced during the course of this research**